2483 5-2500 FIXED MOBILE MOBILE-SATELLITE (space-to-Earlh) 5.351A Radiolocation 5 150 5 371 5.397 5.398 5.399 5 400 5.402	483 5-2500 IXED IOBILE IOBILE-SATELLITE space-to-Earth) 5.351A :ADIOLOCATION :ADIODETERMINATION- SATELLITE (space-lo- Earth) 5.398 ,150 5.402	12483.5-2500 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5 351A RADIOLOCATION **Radiodelerminalion-satellite** (space-lo-Earth) 5 398 5.150 5.400 5.402	183.5-2500 OBILE-SATELLITE ;pace-lo-Earth) US319 S380 ADIODETERMINATION- ATELLITE (space-to- arth) 5.398 150 5.402 US41	2483.5-2500 MOBILE-SATELLITE (space-to-Earth) US319 US380 RADIODETERMINATION- SATELLITE (space-to- Earth) 5.398 5.150 5.402 US41 NG147	M Equipment (18) atellite :ommunications (25) rivate Land Mobile 30) xed Microwave (101)
2500-2520 FIXED 5 409 5 410 5 411 MOBILE except aeronautical mobile 5 384A MOBILE SATELLITE (space to-Earlh) 5 351A 5 403 54055407 54125414	500-2520 IXED 5 409 5 411 IXED-SATELLITE (space-to-Earth) 5 415 IOBILE excepl aeronautical mobile 5 384A IOBILE-SATELLITE (space-to Earth) 5 351A 5 403 .404 5 407 5.414 5.415A		500-2655	2500-2655 FIXED 5.409 5.411 US205 FIXED-SATELLITE (space-lo-Earth) NG102 MOBILE excepl aeronautic, mobile BROADCASTING- SATELLITE NG101	omestic Public Fixed 21) uxiliary Broadcasting 74)
2520 2655 FIXED 5 409 5 410 5 411 MOBILE except aeronautical mobile 5 384A BROADCASTING- SATELLITE 5.413 5.416 5.339 5.403 5.405 5.412 5.418 5.418B 5.418C	520-2655 IXED 5.409 5.411 IXED-SATELLITE (space-to-Earth) 5.415 IOBILE except aeronautical mobile 5.384A BROADCASTING- SATELLITE 5.413 5.416 5.339 5.403 5.418B 5.418C	2520-2535 FIXED 5.409 5.411 FIXED-SATELLITE (space-lo-Earth) 5.415 MOBILE except aeronautic: mobile 5.384A BROADCASTING- SATELLITE 5.413 5.416 5.403 5.415A 2535-2655 FIXED 5.409 5 411 MOBILE except aeronautic: mobile 5.384A BROADCASTING- SATELLITE 5.413 5.416 5.339 5.418 5.418A 5.4188 5.418C	.339 US205 US269	5.339 US269	

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UNITED STATES (US) FOOTNOTES

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US380 In the bands 1525-1544 MHz, 1545-1559 MHz, 1610-1645.5 MHz, 1646.5-1660.5 MHz, 2000-2020 MHz, 2180-2200 MHz, and 2483.5-2500 MHz, a non-Federal Government licensee in the mobile-satellite service (MSS) may also operate an ancillary terrestrial component in conjunction with its MSS network, subject to the Commission's rules for ancillary terrestrial components and subject to all applicable conditions and provisions of its MSS authorization.

* * * * *

PART 25--SATELLITE COMMUNICATIONS

3. The authority citation for Pan 25 continues to read as follows:

AUTHORITY: 47 U.S.C. 701-744. Interprets or applies sec. 303.47 U.S.C. 303. 47 U.S.C. sections 154,301,302,303,307,309 and 332, unless otherwise noted.

4. Section 25.117 is amended to read **as** follows:

§ 25.117 Modification of station license.

* * * * *

(f) An application for modification of a space station license to add an ancillary terrestrial component to an eligible satellite network will be treated **as** a request for a minor modification if the particulars of operations provided by the applicant comply with the criteria specified in § 25.147.

* * * * *

5. Section 25.143 is amended to read **as** follows:

§ 25.143 Licensing provisions for **the 1.6/2.4 GHz mobile-satellite service and the 2 GHz mobile-satellite service.**

* * * * *

(i) Incorporation of ancillary terrestrial component base stations into a 1.6/2.4 GHz mobile-satellite service network or a 2 GHz mobile-satellite service network. Any licensee authorized to construct and launch a 1.6/2.4 GHz or a 2 GHz mobile-satellite system may construct ancillary terrestrial component (ATC) base stations as defined in § 25.201 **of** this pan at its own risk and subject to the conditions specified in this **subpart** any time after commencing construction of the mobile-satellite service system.

(j) Pre-Operational Testing. An **MSS** ATC licensee may. without further authority from the Commission, conduct equipment tests for the purpose of making such adjustments and measurements **as** may be necessary to assure compliance with the terms of the technical provisions of its **MSS** license, its ATC authorization. the rules and regulations in this Part and the applicable engineering standards. An MSS licensee may not offer ATC service to the public for compensation during pre-operational testing. In order to operate any ATC base stations, such a licensee must meet all the requirements set fonh in § 25.147 and must have been granted ATC authority through a modification of its space station license.

(k) Aircraft. ATC mobile terminals must be operated in accordance with 25.136(a). All portable or hand-held transceiver units (including transceiver units installed in other devices that are themselves portable or hand-held) having operating capabilities in the 2000-2020/2180-2200 MHz or 1610-1626.5 MHz/2483.5-2500 MHz bands shall bear the following statement in a conspicuous location on the device: “This device may not be operated while on board aircraft. It must be turned off at all times while on board aircraft.”

* * * * *

6 Section 25.146 is mended to read as follows:

§ 25.146 Licensing provisions for **the L-Band mobile-satellite service.**

* * * * *

(g) Incorporation of ancillary terrestrial component base station into an L-band Mobile-Satellite Service System. Any licensee authorized to construct and launch an L-band mobile-satellite system may construct ancillary terrestrial component (ATC) base stations as defined in § 25.201 of this part at its own risk and subject to the conditions specified in this subpart any time after commencing construction of the mobile-satellite service system.

(h) Pre-Operational Testing. **An** MSS ATC licensee may, without further authority from the Commission, conduct equipment tests for the purpose of making such adjustments and measurements as may be necessary to assure compliance with the terms of the technical provisions of its MSS license, its ATC authorization, the rules and regulations in this Pan and the applicable engineering standards. An **MSS** licensee may not offer ATC service to the public for compensation during pre-operational testing. In order to operate any ATC base stations, such a licensee must meet all the requirements set forth in § 25.147 and must have been granted ATC authority through a modification of its space station license.

(i) Aircraft. All portable or hand-held transceiver units (including transceiver units installed in other devices that are themselves portable or hand-held) having operating capabilities in the 1626.5-1660.5 MHz and 1525-1559 MHz bands shall bear the following statement in a conspicuous location on the device: 'This device may not be operated while on board aircraft. It must be turned off at all times while on hoard aircraft."

* * * * *

7. New Section 25.147 is added to read as follows:

§ 25.147 Application requirements for ancillary terrestrial components in the mobile-satellite service networks operatine in the 1.5J1.6 GHz, 1.6/2.4 GHz and 2 GHz mobile-satellite service.

(a) Applicants for ancillary terrestrial component authority shall demonstrate compliance with the following through certification or explanatory technical exhibit, as appropriate:

(1) ATC shall be deployed in the forward-hand mode of operation whereby the ATC mobile terminals transmit in the MSS uplink bands and the ATC base stations transmit in the MSS downlink bands in portions of the 2000-2020 MHz/2180-2200 MHz bands (2 GHz band). the 1626.5-1660.5MHz/1525-1559 MHz bands (L-band), and the 1610-1626.5MW2483.5-2500 MHz bands (Big LEO band).

(2) **ATC** operations shall be limited to certain frequencies:

(i) In the 2000-2020 MHz/2180-2200 MHz bands *(2* GHz MSS band), ATC operations are limited to the selected assignment of the 2 GHz MSS licensee that seeks ATC authority.

(ii) In the 1626.5-1660.5MHz/1525-1559 MHz bands (L-band), ATC operations are limited to the frequency assignments authorized and internationally coordinated for the MSS system of the **MSS** licensee that seeks ATC authority.

(iii) In the 1610-1626.5MHz/2483.5-2500 MHz bands (Big LEO band), ATC operations are limited to the 1610-1615.5 MHz, 1621.35-1626.5MHz. and 2492.5-2498.0 MHz bands and to the specific frequencies authorized for use **by** the MSS licensee that seeks ATC authority.

(3) ATC operations shall not exceed the geographical coverage area of the mobile-satellite service network of the applicant for ATC authority.

(4) ATC base stations shall comply with all applicable antenna and structural clearance requirements established in Pan 17 of the Commission's rules.

(5) ATC base stations and mobile terminals shall comply with Pan 1 of the Commission's rules, Subpart I – Procedures Implementing the Notional Environmental Policy Act of 1969. including

the guidelines for human exposure to radio frequency electromagnetic fields as defined in §§ 1.1307(b) and 1.1310 of the Commission's rules for PCS networks.

(6) ATC base station operations shall use less than all available MSS frequencies when using all available frequencies for ATC base station operations would exclude otherwise available signals from MSS space-stations.

(b) Applicants for an ancillary terrestrial component shall demonstrate compliance with the following criteria through certification:

(1) Geographic and Temporal Coverage.

(i) For the 2 GHz MSS band. an applicant must demonstrate that it can provide space-segment service covering all 50 states. Puerto Rico. and the U.S. Virgin Islands one-hundred percent of the time, consistent with the coverage requirements for 2 GHz MSS GSO operators.

(ii) For the L-band, an applicant must demonstrate that it can provide space-segment service covering all 50 states, Puerto Rico. and the U.S. Virgin Islands one-hundred percent of the time, unless it is not technically possible for the MSS operator to meet the coverage criteria from its orbital position.

(iii) For the Big LEO band, an applicant must demonstrate that it can provide space-segment service (i) to all locations as far north as 70° North latitude and as far south as 55° South latitude for at least seventy-five percent of every 24-hour period, i.e., that at least one satellite will be visible above the horizon at an elevation angle of at least 5" for at least 18 hours each day, and (ii) on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands, i.e., that at least one satellite will be visible above the horizon at an elevation angle of at least 5" at all times.

(2) Replacement Satellites.

(i) Operational NGSO MSS ATC systems shall maintain an in-orbit spare satellite.

(ii) Operational GSO MSS ATC systems shall maintain a spare satellite on the ground within one year of commencing operations and launch it into orbit during the next commercially reasonable launch window following a satellite failure.

(iii) All MSS ATC licensees must report any satellite failures. malfunctions or outages that may require satellite replacement within ten days of their occurrence.

(3) Commercial availability. Mobile-satellite service must be commercially available (*viz.*, offering services for a fee) in accordance with the coverage requirements that pertain to each band as a prerequisite to an MSS licensee's offering ATC service.

(4) Integrated Services. MSS licensees shall offer an integrated service of MSS and MSS ATC. Applicants for MSS ATC may esrablish an integrated service offering by affirmatively demonstrating that:

(i) The MSS ATC operator will use a dual-mode handset that can communicate with both the MSS network and the MSS ATC component to provide the proposed ATC service;or,

(ii) Other evidence establishing that the MSS ATC operator will provide an integrated service offering to the public.

(5) In-band Operation.

(i) In the 2 GHz MSS band. MSS ATC is limited to an MSS's licensee's selected assignment. MSS ATC operations beyond the MSS licensee's selected assignment are prohibited.

(ii) In the Big LEO band. MSS ATC is limited to no more than 5.5 MHz of spectrum in each direcrion of operation. Licensees in these bands may implement ATC only on those channels on which MSS is authorized. consistent with the Big LEO band-sharing arrangement.

(iii) In the L-band, MSS ATC is limited to those frequency assignmenrs available for MSS use in accordance with the Mexico City Memorandum of Understanding, its successor agreements or the result of other organized efforts of international coordination.

(c) Equipment cenification.

(1) Each ATC MET utilized for operation under this pan and each transmitter marketed, as set forth in Sec. 2.803 of this chapter, must be of a type that has been authorized by the Commission under its certification procedure for use under this part.
(2) Any manufacturer of radio transmitting equipment to be used in these services may request equipment authorization following the procedures set forth in subpart J of pan 2 of this chapter. Equipment authorization for an individual transmitter may be requested by an applicant for a station authorization by following the procedures set forth in part 2 of this chapter.
(3) Licensees and manufacturers are subject to the radiofrequency radiation exposure requirements specified in 1.1307(b), 2.1091 and 2.1093 of this chapter, as appropriate. MSS ATC base stations must comply with the requirements specified in 1.1307(b) for PCS base stations. MSS ATC mobile terminals must comply with the requirements specified for mobile and portable PCS transmitting devices in 1.1307(b). MSS ATC mobile terminals must also comply with the requirements in 2.1091 and 2.1093 for Satellite Communications Services devices. Applications for equipment authorization of mobile or portable devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. Technical information showing the basis for this statement must be submitted to the Commission upon request.

(d) Applicants for an ancillary terrestrial component authority shall demonstrate compliance with the provisions of §§ 1.924 and 25.203(e)-(g) and with §§ 25.252. 25.253, or 25.254, as appropriate, through certification or explanatory technical exhibit.

(e) Upon receipt of ATC authority, all ATC licensees must ensure continued compliance with this section and §§ 25.252, 25.253. or 25.254, as appropriate.

8. Section 25.201 is amended by amending and adding the following definitions in alphabetical order to read as follows:

§ 25.201 Definitions.

* * * * *

Ancillary terrestrial component. The term "ancillary terrestrial component" means a terrestrial communications network used in conjunction with a qualifying satellite network system authorized pursuant to these rules and the conditions established in the Report and Order issued in IB Docket 01-185, Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band.

Ancillary terrestrial component base station. The term "ancillary terrestrial component base station" means a terrestrial fixed facility used to transmit communications to or receive communications from one or more ancillary terrestrial component mobile terminals.

Ancillary terrestrial component mobile terminal. The term "ancillary terrestrial component mobile terminal" means a terrestrial mobile facility used to transmit communications to or receive communications from an ancillary terrestrial component base station or a space station.

Selected assignment. The term "selected assignment" means a spectrum assignment voluntarily identified by a 2 GHz MSS licensee at the time that the licensee's first 2 GHz mobile-satellite service satellite reaches its intended orbit. or other mobile-satellite service spectrum in which the Commission permits a 2 GHz mobile-satellite service licensee to conduct mobile-satellite service operations with authority superior to that of other in-band. mobile-satellite service licensees.

Structural attenuation. The term "structural attenuation" means the signal attenuation caused by transmitting to and from mobile terminals which are located in buildings or other man-made structures that attenuate the transmission of radiofrequency radiation.

* * * * *

9. New Section 25.252 is added to read as follows:

§ 25.252 Special requirements for ancillary terrestrial components operating in the 2000-2020 MHz/2180-2200 MHz bands.

(a) Applicants for an ancillary terrestrial component in these bands must demonstrate that **ATC** base stations shall not:

(I) exceed -100.6 dBW/4 kHz out-of-channel emissions at the edge of the **MSS** licensee's selected assignment.

(2) exceed a peak EIRP of 27 dBW in 1.23 MHz.

(3) exceed an EIRP toward the physical horizon (not to include man-made structures) of 25.5 dBW in 1.23 MHz.

(4) be located less than 190 meters from all airpon runways and aircraft stand areas, including takeoff and landing paths.

(5) exceed an aggregate power flux density of -51.8 dBW/m^2 in a 1.23 MHz bandwidth at all airpon runways and aircraft stand areas, including takeoff and landing paths and **all** ATC base station antennas shall have **an** overhead gain suppression according to the following.

(6) be located less than 820 meters from a U.S. Eanh Station facility operating in the 2200-2190 MHz band. In its MSS ATC application. the **MSS** licensee should request a list of operational stations in the 2200-2190 MHz band.

(7) exceed an EIRP in the 1559-1605 MHz band of -70 dBW/MHz for wideband emissions and **-80** dBW for narrow-band emissions. The wideband EIRP level is to be measured using a root mean square (RMS) detector function with a minimum resolution bandwidth of 1 MHz and the video bandwidth is not less than the resolution bandwidth. The narrowband **EIRP** level is to be measured using an RMS detector function with a resolution bandwidth of no less than I kHz. The measurements are to be made over a 20 millisecond averaging period when the base station is transmitting data.

Angle from Direction of Maximum Gain. in Vertical Plane, Above Antenna (Degrees)	Antenna Discrimination Pattern (dB)
0 to 15	Meet or exceed ITU-R Rec. F.1336, Annex 1. for P-

Angle from Direction of Maximum Gain. in Vertical Plane. Above Antenna (Degrees)	Antenna Discrimination Pattern (dB)
0	Gmax
2	Not to Exceed Gmax – 14
8 to 180	Not to Exceed Gmax – 25

Nominal Mobile Terminal Peak EIRP	Mobile Terminal Transmit Duty Cycle
Equal to or less than -7.4 dBW	100%
Greater than -7.4 dBW	50%
Greater than -4.4 dBW	25%

Greater than - 1.4 dBW	20%
Greater than -0.4 dBW	18.2%

(3) implement the provisions of subsection (2) in a manner that precludes other ATC mobile terminals from using the open time slots.

(4) demonstrate, at the time of application, how the ATC network will comply with the requirements of subsections (a) and (b)(1) through (b)(3) above.

(5) demonstrate, at the time of application. how its ATC network will comply with the requirements of footnotes **US308** and **US315** to the table of frequency allocations contained in § 2.106 *of* the Commission's rule regarding priority and preemptive access to the L-band MSS spectrum by the aeronautical mobile-satellite en-route service (AMS(R)S) and the global maritime distress and safety system (GMDSS).

(6) demonstrate how its ATC network base stations and mobile terminals will comply with the Global Mobile Personal Communications by Satellite (GMPCS) system requirements to protect the radionavigation satellite services (RNSS) operations in the allocation above 1559 MHz.

(7) coordinate with the terrestrial CMRS operators prior to initiating ATC transmissions when co-locating ATC base stations with terrestrial commercial mobile radio service (CMRS) base stations that make use of Global Positioning System (GPS) time-based receivers.

(8) demonstrate that the cellular structure of the ATC network design includes **18** dB of link margin allocated to structural attenuation. If less structural attenuation is used, the maximum number of base stations permitted under paragraph (c) of this section must be reduced or a showing must be made that there would be no increase in interference to other **MSS** operators and that the applicant's satellite would continue to meet the other requirements of this section.

(b) ATC base stations shall not exceed an out-of-channel emissions measurement of -57.9 dBW/MHz at the edge of **a** MSS licensee's authorized and internationally coordinated MSS frequency assignment.

(c) The maximum number of base stations operating in the U.S. on any one 200 kHz channel shall not exceed **1725.** During the first 18 months following activation for testing of the first ATC base station, the L-band ATC operator shall not implement more than 863 base stations on the same 200 kHz channel. L-band ATC operators shall notify the Commission of the date of the activation for testing of the first ATC base station and shall maintain a record of the total number of ATC base stations operating in the U.S. on any given 200 kHz of spectrum. Upon request by the ***Commission,*** L-band ATC operators shall provide this information to resolve any claim it receives from an L-band MSS operator that ATC operations are causing interference to its MSS system.

(d) Applicants for an ancillary terrestrial component in these bands must demonstrate that ATC base stations shall not:

(1) exceed peak EIRP of 19.1 dBW, in 200 kHz, per carrier with no more than three carriers per sector;

(2) exceed an EIRP toward the physical horizon (not to include man-made structures) of 14.1 dBW per carrier in 200 kHz;

(3) locate any ATC base station less than 470 meters from all airport runways and aircraft stand areas. including takeoff and landing paths;

(4) exceed an aggregate power flux density level of **-73.0** dBW/m^2/200 **kHz** at the edge all airport runways and aircraft stand areas. including takeoff and landing paths;

(5) locate any ATC base station less than 1.5 km from the boundaries of all navigable waterways or the ATC base stations shall not exceed a power flux density level of -64.6 dBW/m^2/200 kHz at the water's edge of any navigable waterway;

(6) exceed a peak gain of 16 dBi;

(7) exceed **an** EIRP in the 1559-1605 MHz band of -70 dBW/MHz for wideband emissions and -80 dBW for narrow-band emissions. After January 1, 2005. the ATC station shall not exceed an EIRP in the 1605-1610 MHz frequency range that is determined by linear interpolation from –70 dBW/MHz at 1605 MHz to –10 dBW/MHz at 1610 MHz for wideband emissions. The wideband

Angle from Direction of Maximum Gain, in Vertical Plane, Above Antenna (Degrees)	Antenna Discrimination Pattern (dB)
0	Gmax
5...	Not to Exceed Gmax – 5
10..	Not to Exceed Gmax -19
15 to 30......................................	Not to Exceed Gmax – 27
30 to 55......................................	Not to Exceed Gmax – 35
55 to 145	Not to Exceed Gmax – 40
145 to 180....................................	Not to Exceed Gmax – 26

(f) Prior to operation, ancillary terrestrial component licensees shall:

(1) provide the Commission with sufficient information to complete coordination of ATC base stations with Search-and-Rescue Satellite-Aided Tracking (SARSAT) earth stations operaling in the 1544-1545 MHz band for any ATC base station located either within 27 km of a SARSAT station, or within radio horizon of the SARSAT station, whichever is less.

(2) take all practicable steps to avoid locating ATC base stations within radio line of sight of MAT receive sites in order to protect U.S. MAT systems consistent with ITU-R Recommendation ITU-R M.1459. MSS ATC base stations located within radio line of sight of a MAT receiver must be coordinated with the Aerospace and Flight Test Radio Coordinating Council (AFTRCC) for non-Government MAT receivers on a case-by-case basis prior to operation. For government MAT receivers. the MSS licensee shall supply sufficient information to the Commission to allow coordination to take place. A listing of current and planned MAT receiver sites can be obtained from AFTRCC for non-Government sites and through the FCC's IRAC Liaison for Government MAT receiver sites.

(g) Applicants for an ancillary terrestrial component in these bands must demonstrate that ATC mobile terminals shall:

(1) be limited to a peak EIRP level of 0 dBW and an out-of-channel emissions of -67dBW/4 kHz at the edge of a MSS licensee's authorized and internationally coordinated MSS frequency assignment.

(2) take all practicable steps to avoid ATC mobile terminals from causing interference to U.S. radio astronomy service (RAS) observations in the 1660-1660.5MHz band.

(3) not exceed an EIRP in the 1559-1610 MHz band of -70 dBW/MHz for wideband emissions and -80 dBW for narrow-band emissions. The wideband EIRP level is to be measured using a root mean square (RMS) detector function with a minimum resolution bandwidth of 1 MHz and the video bandwidth is not less than the resolution bandwidth. The narrowband EIRP level is to be measured using an RMS detector function with a resolution bandwidth of no less than 1 kHz. The measurements arc to be made over a 20 millisecond averaging period when the base station is transmitting data.

Note: The preceding rules of § 25.253 are based on GSM/TDMA 800 or GSM 1800 system architecture. To the extent that an L-band MSS licensee is able to demonstrate that the use of a different system architecture would produce no greater potential interference than that produced as a result of implementing the rules of this section, an MSS licensee is permitted to apply for ATC authorization based on another system architecture.

11. New Section 25.254 is added to read as follows:

§ 25.254 Special [illegible] for ancillary terrestrial components operating in the 1610-1626.5 MHz/2483.5-2500 MHz bands.

(a) An applicant for an ancillary terrestrial component in these bands must demonstrate that ATC base stations shall:

(1) not exceed a peak EIRP of 32 dBW in 1.25 MHz;

(2) not cause unacceptable interference to systems identified section 25.254(c) and, in any case, shall not exceed out-of-channel emission of -44.1 dBW/30 kHz at the edge of the MSS licensee's authorized frequency assignment;

(3) at the time of application, that it has taken, or will take steps necessary to avoid causing interference to other services sharing the use of the 2450-2500 MHz band through frequency coordination: and

(4) not exceed an EIRP in the 1559-1605 MHz band of -70 dBW/MHz for wideband emissions and -80 dBW for narrow-band emissions. After January 1, 2005. the ATC station shall not exceed an EIRP in the 1605-1610 MHz frequency range that is determined by linear interpolation from –70 dBW/MHz at 1605 MHz to –10 dBW/MHz at 1610 MHz for wideband emissions. The wideband EIRP level is to be measured using a root mean square (RMS) detector function with a minimum resolution bandwidth of 1 MHz and the video bandwidth is not less than the resolution bandwidth. The narrowband EIRP level is to be measured using an RMS detector function with a resolution bandwidth of no less than 1 kHz. The measurements are to be made over a 20 millisecond averaging period when the base station is transmitting data.

(b) An applicant for an ancillary terrestrial component in these bands must demonstrate that mobile terminals shall:

(1) meet the requirements contained in § 25.213 to protect radio astronomy service (RAS) observations in the 1610.6-1613.8 MHz band from unacceptable interference;

(2) observe a peak EIRP limit of 1.0 dBW in 1.25 MHz;

(3) observe an out-of-channel EIRP limit of -57.1 dBW/30 kHz at the edge of the licensed MSS frequency assignment.

(4) not exceed an EIRP in the 1559-1605 MHz band of -70 dBW/MHz for wideband emissions and -80 dBW for narrow-band emissions. The wideband EIRP level is to be measured using a root mean square (RMS) detector function with a minimum resolution bandwidth of 1 MHz and the video bandwidth is not less than the resolution bandwidth. The narrowband EIRP level is to be measured using an RMS detector function with a resolution bandwidth of no less than 1 kHz. The measurements are to be made over a 20 millisecond averaging period when the base station is transmitting data.

(c) Applicants for an ancillary terrestrial component to be used in conjunction with a mobile-satellite service system using CDMA technology shall coordinate the use of the Big LEO MSS spectrum designated for CDMA systems using the framework established by the ITU in Recommendation ITU-R M.1186.

Note: The preceding rules of § 25.254 are based on cdma2000 and IS-95 system architecture. To the extent that a Big LEO MSS licensee is able to demonstrate that the use of different system architectures would produce no greater potential interference than that produced as a result of implementing the rules of this section, an MSS licensee is permitted to apply for ATC authorization based on another system architecture.

12. New Section 25.255 is added to read as follows:

§ 25.255 Procedures for resolving harmful interference related to operation of ancillary terrestrial components operating in the 1.5/1.6 GHz, 1.6/2.4 GHz and 2 GHz bands.

If harmful interference is caused to other services by ancillary MSS ATC operations, either from ATC base stations or mobile terminals, the ATC operator must resolve any such interference. If the MSS ATC operator claims to have resolved the interference and other operators claim that interference has not been resolved, then the parties to the dispute may petition the Commission for a resolution of their claims.

APPENDIX C1: TECHNICAL EVALUATION OF 2 GHz MSS ATC PROPOSALS

1.0 Assessment of Assumptions Used in Technical Analysis

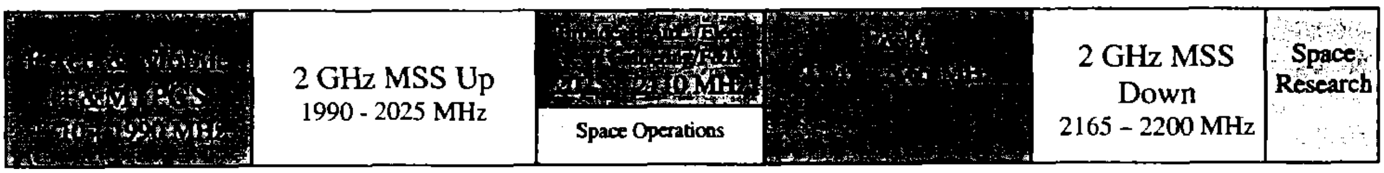
ICO, a 2 GHz mobile satellite service (MSS) licensee, submitted a proposal for an Ancillary Terrestrial Component (ATC) system to operate in conjunction with its MSS System. In its **ATC** proposal, ICO does not specifically define which bands it would use for the base stations (BS) and user mobile terminal (MT) transmitters. Instead, IC0 lists four possible modes of implementing the ATC system. As shown in the following Table, the consideration of the four possible ATC modes requires that proposed MT and BS transmitter operations be analyzed for compatibility in both the MSS uplink (1990-2025 MHz) and MSS downlink (2165-2200 MHz) frequency bands.

Implementation Scheme	**MSS** Uplink Band	**MSS** Downlink Band
Uplink Hybrid	BS and MT	
Downlink Hybrid		BS and MT
Forward Band	MT	**BS**
Reverse Rand	**RS**	MT

In addition to the MSS uplink and downlink bands, the IC0 ATC proposal potentially affects the operations of systems in adjacent frequency bands shown in the Figure 1 below. In general there are two different situations: adjacent assignment and adjacent allocation. This appendix analyzes the potential interference to MSS systems operating within the MSS frequency allocation on MSS assignments adjacent to ICO's MSS selected assignment and to other types of communication systems operating in allocations adjacent to the MSS allocations.

The adjacent allocation situation occurs at the allocation boundary between the **MSS** and the services that operate in the adjacent bands. The adjacent assignment situation occurs between ICO and the **MSS** systems that will occupy adjacent MSS assignments within the MSS Allocation. Co-frequency sharing between an MSS system and the terrestrial fixed systems which currently occupy the 2 GHz **MSS** allocations has been addressed in the *2* GHz Service Rules Report and Order and is not a topic of this Technical Appendix.[1]

Figure 1 - 2 GHz **MSS** and Adjacent Allocated Bands



1.1 Out-of-Band Emission Levels

ICO states that the ATC transmitters will either operate in the ICO **MSS** assignment or, on a secondary basis, within the MSS assignment of another MSS licensee. In the Forward Band and Reverse Band modes both MT and BS transmitters will operate within the IC0 MSS assignments. In the Uplink Hybrid and Downlink Hybrid modes ICO states that the MT and BS would both transmit in the MSS uplink and

[1] *See Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2* **GH; *Band***, IB Docket No 99-81, Report and Order, 15 FCC Rcd 16117 (2000)(*2 GHz MSS Rules Order*).

downlink, respectively. The co-channel compatibility of the ICO ATC transmitters and other MSS systems is not the subject of this appendix. This appendix specifically addresses the out-of-band compatibility between the ICO ATC transmitters and other MSS systems and communication systems operating in frequency allocations adjacent to the MSS allocations.

The ICO ATC proposal provided technical details of a 3G PCS system **as** a representative ATC system.[2] The 3G system selected by ICO was CDMA2000. The out-of-channel emission values associated with the CDMA2000 system are shown in Table 1.1.A.[3]

Table l.l.A ICO Proposed ATC Out-of-Band Emission Values

Out-of-Channel EIRP	**MT**	**BS**
700-750 kHz offset from center	-53.3 dBW/4kHz	**-16.3** dBW/4kHz
>750 kHz offset from center	-93.5 dBW/4kHz	-56.5 dBW/4kHz

In January of 2002, ICO submitted an ex pane letter which readdressed the out-of-channel emissions from its proposed ATC system. The following table, Table 1.1.B, shows the out-of-band emission limits proposed by IC0 in its *ex parte* comments.[4] These are emission levels that ICO states would occur at the edge **of** its **MSS** assignment.

Table l.l.B ICO Out-of-Band Values

Equipment	**MSS Uplink Band**	**MSS Downlink Band**
MS[illegible] U[illegible] Ter[illegible] i[illegible] ATC [illegible]	67.0 dBW/4kHz	·119.6 dBW/4kHz
ATC Bas[illegible] Stati[illegible]	[illegible]7.0 dBW/4kHz	·100.6dBW/4kH

ICO states that "[t]hese limits should be measured at the transmitter (whether base station or user MT) in the receive band assigned to the adjacent MSS systems. The limits for **MSS** uplink spectrum are identical to the PCS emission limits in Section 24.238 of the Commission's Rules. The limits for the downlink spectrum are more stringent. in recognition of the fact that ATC operations in MSS downlink spectrum likely represents a greater interference threat to MSS operations."[5] ICO is correct that for a PCS system with a transmit power of *1* Waft, the limiting emission it quotes for the **MSS** uplink band is consistent with section 24.238. The limits listed for the **MSS** downlink band are significantly below the level specified by section 24.238.

The limits included in Table 1.1.A were used by other commenters to evaluate the potential impact of the proposed ICO ATC system on their systems. The later limits, contained in Table 1.1.B, are significantly different than those in Table 1.1.A and will be used in our analyses to assess the potential interference between the IC0 ATC transmitters and MSS systems in adjacent bands and other systems in adjacent allocations

[2] ICO **Mar.** 8.2001 *Ex Parte* Letter, App. B at 10

[3] ICO **Mar.** 8. 2001 ***Ex fane*** Letter. App. B at 11

[4] IC0 Apr. **10.** 2002 *Ex Parte* Letter at *2*

[5] ICO Apr. 10. 2002 *Ex Parte* Letter at 2

1.2 Other Assumptions Used in Technical Analysis

1.2.1 Voice Activation

ICO states that additional factors may reduce the level of out-of-band (OOB) emissions from both the ATC MTs and **BS** transmitters. In particular. ICO asserts that a voice activation factor of **4 dB**.[6] or 40%. is appropriate when dealing with a population of PCS-like transmitters. While the actual value of the voice activations factor will depend upon the level of background noise experienced by the users. typical values do range from 1 to **4** dB.[7]

1.2.2 Power Control

ICO also claims that a power control factor of 4.77 dB is appropriate and conservative to use with a large population of PCS-like transmitters.' Other commenters in this proceeding have used values of a power control factor ranging from *2* to 6 dB. Our independent evaluation of terrestrial cellular network power control leads us to the conclusion that ATC networks would incorporate a power control factor of 10 dB, or greater, in sharing analyses for the ATC network.' Several factors that minimize the BS and MT power usage including the following: structural attenuation.'' BS/MT range variation and body blockage. The purpose of reducing the power usage is to reduce the cell-to-cell interference and to prolong MT battery life. Typical structural attenuation factors are on the order of 10 dB or greater; BS/MT range variations are on the order of *6* dB; and body blockage is approximately **2-4** dB. The actual dynamic range of the power control system is expected to be greater than the sum of the individual attenuation factors. We use a 10 dB power control factor for MT transmissions in our analysis of **2** GHz ATC operations. A more detailed discussion of these factors is provided in Appendix C2 **1.3.**

1.2.3 Frequency Polarization Isolation

Some frequency polarization isolation will exist between a transmitter and receiver using different polarization schemes. In comments submitted with regard to this proceeding Inmarsat references a value of 1.4 dB for polarization isolation for all cases of linear to circular, non-identical polarization mismatch between a PCS-like transmitter and a satellite transmitter." **MSV** argued that when considering an ensemble of randomly oriented linear emitters received by a circularly polarized receiver, a value of **3** dB would be more appropriate to use.[12] Because the orientation of the linear transmit ATC antennas will not be truly random,'' a more conservative 1.4dB number proposed **by** Inmarsat is taken into account in our

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[b] ***See*** ICO **Jan.** 29.2002 *Ex* ***Pane*** Letter at **3.**

[7] **See** *infra* **App.** C2, L-band Technical **App.,** § I

[8] *See* ICO Jan. 29, 2002 *Ex Parte* Letter ar 4.

[V] *See infra* App. C2, § 1.3 for a detailed discussion on the use of power control in cellular systems

[10] By "structural attenuation" we mean the signal attenuation that takes place when an MT transmits within a building. automobile or other structure [hat completely encloses the MT. We differentiare between "structural attenuation" and "outdoor blockage" of the line-of-sight propagation path between a transmitter and a satellite receiver caused by obstacles such as buildings and trees.

[11] Inmarsat Comments at 27.

[12] MSV Reply at 8

[13] It is expected that the **ATC** handset antennas will be oriented in some distribution about the local vertical and not have an equal probability of being oriented in all direction,.

analyses. We believe that these arguments, made with respect to L-band MSS operations, are also applicable to 2 GHz MSS.

1.2.4 Receiver Saturation Level

Some parties have argued that their mobile earth stations (MES) will "overload," or saturate. when exposed to **-120** dBW of interfering power within the RF band-pass of the receiver.[14] This level is equivalent to -90 dBm. Other parties have provided measurements of an L-band terminal that showed that saturation did not occur until the input power reached about -45 dBm, some **45** dB higher than -90 dBm.[15] Additionally, some parties have quoted the Radio Technical Committee on Aeronautics (RTCA) as having a standard for -50 dBm for airborne terminals. Given these potential values for saturation we feel that the use of -50 dBm for airborne terminals and *-60* dBm for **mass** produced terrestrial receivers is reasonable. Therefore, we will use a value of -60 dBm in our *2* GHz analyses, except in cases where one of the parties specifically states that it can use a receiver that is less susceptible to saturation.

2.0 Intra-Service (Adiacent Assignment) Interference Analvses

The *2* GHz processing round resulted in the licensing of eight (8) MSS systems in 70 MHz of spectrum. As contained in the *2* GHz **R&O**,[16] this spectrum will be divided among the licensees who are successful in implementing their systems. Upon the launch of its first satellite, an MSS licensee must declare a portion of the 2 GHz spectrum as "home" spectrum. Each licensee **will** also be permitted to operate in additional 2 GHz MSS spectrum on a **non-harmful-interference** basis. Because each MSS systems will operate alone in its home spectrum, intra-service sharing is not a co-frequency sharing situation. There is however. a potential for interference to the MSS systems operating in the adjacent frequency assignment. Boeing is the only MSS licensee that has provided detailed comments concerning the potential that the ICO ATC system may cause interference to another *2* GHz MSS system. We evaluate the impact that **2** GHz ATC as proposed by ICO would have on Boeing's MSS system.

2.1 MSS Uplink Band **(1990-2025 MHz)**

ICO has proposed three possible ATC modes that would place transmitters in the MSS uplink band;

(1) Forward Band Mode that would implement **ATC** MTs in the MSS uplink band;

(2) Reverse Band Mode that would put ATC base stations in the MSS uplink band; and

(3) Uplink Duplex Mode that implements both the ATC MT and BS in the MSS uplink band

The following addresses the potential for intra-service, adjacent channel interference among the MT and BS transmitters in the MSS uplink band.

2.1.1 Analysis **of** Potential Interference **to** Adjacent **MSS** Assignments **-** **MSS** Uplink Band

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[14] *Inmarsat Comments, Technical* Annex § 3.3.1. When relevant, *we* distinguish between mobile earth stations (MES) and mobile terminals (MTs). We **use** the term "MES" to identify terminals **that** communicate **only** with an MSS system We **use** the term "MT" to identify terminals that communicate with either **the** MSS system or its **ATC.**

[15] *See* MSV Reply. Technical **App.** at 14.

[16] *2 GHz MSS Rules Order*. 15 FCC Rcd at 16174-81, ¶¶ 99-116

Boeing submitted initial comments indicating that, based upon a number of assumptions, it is concerned about possible interference from the ATC BS to satellite uplink receivers." However. it indicates that no problem should be encountered from the ATC MT to satellite uplinks. As mentioned earlier, this scenario is an adjacent channel sharing situation. as each MSS system will be assigned its own home spectrum and must operate on a non-interference basis in any other pan of the **MSS** allocation. The following sections compare Boeing's analysis with our independent analysis.

2.1.2 Interference to Boeing Satellite Receiver from ATC Base Stations

Boeing provides a link calculation which uses a 6% increase in the satellite receiver noise as the interference criteria.[18] The result of the Boeing calculations indicate a positive margin at the satellite of about 5 dB. Based upon this margin Boeing expressed concern about the potential for interference and suggested that **an** aggregate base station power limit might be appropriate.

The Boeing calculation describes an interference link from a number of base stations at the edge of coverage (10 degree elevation) of the Boeing **MSS** satellite spot beam. It assumes that there are ***500*** base stations and that they are located on this 10 degree elevation contour. The third column of Table 2.1.2.A is reproduced from the Boeing Comments and is included for comparison purposes. The Boeing analysis is based upon the satellite being visible at the base station at an elevation angle of 10 degrees and corresponds to a calculated path loss of –186.3 dB as shown in the table. The Boeing analysis also assumes that the mainbeam EIRP of all 500 base stations are coupled into the mainbeam of the satellite receive antenna at the base station mainbeam gain. Based upon the 10 degree elevation angle and a -2.5 degree base station antenna tilt proposed by ICO,[19] the angle between the base station peak gain direction and the Boeing satellite would be 12.5 degrees vertically. Using the reference radiation pattern in ITU-R Rec. F.1336. shown in Figure 2.1.2.A, at 12.5 degrees off axis. the base station antenna can be expected to have about 11.5 dB of gain discrimination from the main beam gain. Additionally, the ATC BS out-of-band emission has been reduced from the -56.6 dBW/4kHz in the initial ICO proposal, and assumed **by** Boeing, to the value in Table 1.1.A. These two factors combine to increase the calculated margin from the 4.6 dB calculated by Boeing to 26.6 dB as shown in the fourth column of Table 2.1.2.A.

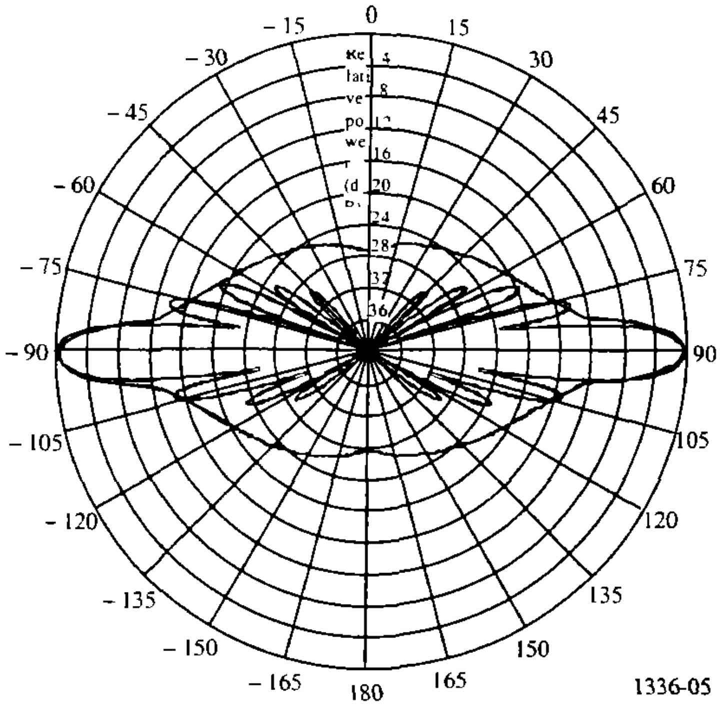
[17] *See generally* Boeing Comments. **App. A.**

[18] *See* Boeing Comments. **App. A** at 5.

[19] This is typical of CDMA2000 base stations. *See* ICO Mar. 8, 2001 *Ex Parte* Letier, **Annex** B at 11

Figure 2.1.2.A Antenna Radiation Pattern of Rec. ITU-R F.1336

Comparison of measured pattern and reference radiation pattern envelope for an omnidirectional antenna with 11 dBi gain and operating in the band 928-944 MHz, $k = 0$



ICO states that it will implement a maximum gain suppression for base station antennas of 25 dB.[20] This value appears to be feasible to meet and is supported by the measured antenna pattern in Figure 2.1.2.A. This indicates that the link analysis presented in the fourth column of Table 2.1.2.A is conservative. Additionally, no account has been taken of the polarization isolation that would exist between the ICO base station and the Boeing satellite receiver. Boeing's analysis suggests that there should be a limit on the aggregate base station power. According to our analysis. such a limit is not necessary.

[20] ICO Mar. 8. 2001 *Ex Parte* Letter. Annex B at 17

Table 2.1.2.A - Interference to Boeing Satellite Receiver from ATC Base Station

Parameters	Units	Boeing Analysis	Modified Boeing Analysis
Frequency	(GHz)	2.0	2.0
ICO OOB Base Station Emission	(dBW/4kHz)	-56.5	-67.0
Number of Base Stations Visible	(#)	500	500
OOB Reference Bandwidth	(kHz)	4.0	4.0
OOB Emission Density *(500* Stations)	(dBW/Hz)	-65.5	-76.0
Satellite Altitude	(km)	20182	20182
Minimum Elevation Angle	(deg)	10	10
Range to Satellite	(km)	24699	24699
Path Loss	(dB)	-186.3	-186.3
Base Station Gain Isolation	(dB)	0	-11.5
Satellite Receive Gain	(dBi)	33.0	33.0
Polarization Isolation	(dB)	0.0	0.0
Interference Density (Io)	(dBW/Hz)	-218.8	-240.8
Satellite Receive Noise Temp	(K)	450	450
Noise Density (No)	(dBW/Hz)	-202.1	-202.1
Interference to Noise Io/No	(dB)	-16.8	-38.8
Io/No Required for 6% Increase in No	(dB)	-12.2	-12.2
Margin	(dB)	4.61	26.6

2.1.3 Interference to Boeing Satellite Receiver from ATC User Terminals

Boeing's initial analysis[21] showed that it did not expect interference problems from ATC MTs in the satellite uplink band. Its calculation assumed 10,000 MTs visible in the Boeing satellite antenna beam. The link calculation predicted a margin of 25 dB at the satellite receiver. However, this analysis was based upon the out-of-channel emission value of –93.5 dBW/4 kHz for the MT contained in the initial ICO proposal. In its latest filing[22] describing out-of-band emission levels. ICO has stated that the out-of-channel emission from a MT in the MSS uplink band would be -67.0 dBW/4kHz. Table 2.1.3.A contains a copy of the Boeinp analysis, in the third column, and a similar analysis using the most recent ICO out-of-channel emission values. Incorporated in the right-most column is a 1.4dB value for frequency polarization isolation. which applies to the case of multiple linear transmitters being received by a circularly polarized receiver. The right-most column of Table 2.1.4.A shows that, using the latest ICO MT out-of-channel values, there is virtually no margin at the Boeing satellite receiver. Therefore. the use of the Section 24.238 emission limitations. alone. for the ICO MT, creates the potential for interference to occur to the Boeing satellite receiver.

[21] Boeing Comments Oct 19, 2001, **App A.** Table 4

[22] *See* ICO *Ex* ***Parrr*** Letter, April 10, 2002 at *2*

Table 2.13.A - Interference to Boeing Satellite Receiver from ATC User Terminals

Parameters	Units	Boeing	Staff
Frequency	(GHz)	2.0	2.0
ICO OOB ATC MT emission	(dBW/4kHz	-93.5	-67.0
Number Terminal Stations Visible	(#)	10000	10000
OOB Reference Bandwidth	(kHz)	4.0	4.0
OOB Emission Density 10.000 Terminal	(dBW/Hz)	-89.5	-63.0
Satellite Altitude	(km)	20182	20182
Elevation Angle	(Deg)	90	90
Range to Satellite	(km)	20182	20182
Path Loss to Satellite	(dB)	-184.6	-184.6
Satellite Receive Gain	(dBi)	34.8	34.8
Polarization Isolation	(dB)	0.0	-1.4
Interference Density (lo)	(dBW/Hz)	-239.3	-214.2
Satellite Receive Noise Temp	(K)	450	450
Noise Density (No)	(dBW/Hz)	-202.I	-202.1
Interference to Noise lo/No	(dB)	-37.2	-12.1
lo/No Required for 6% Delta T/T	(dB)	-12.2	-12.2
Margin	(dB)	25.0	-0.1

As shown in Table 2.1.3.A the section 24.238 OOB limits used with Boeing's link budget essentially results in no link margin. This analysis, however, does not include the mitigating effects of ATC power control and voice activation on sharing with the Boeing system. These two factors combine to decrease the average power emitted towards the Boeing satellite receiver by 8.77 dB according to the values for these factors proposed by ICO. Our independent review on the use of power control in ATC networks suggests that a factor of 10 dB or more would be appropriate to use." Incorporating these two factors into the analysis reduces the increase in noise at the Boeing receiver to less than 1% increase in effective receiver noise temperature. This level of interference to the Boeing satellite receiver should be acceptable.

2.2 MSS Downlink Band (2165-2200 MHz)

2.2.1 Analysis of Adjacent MSS assignments (Boeing airborne receivers)

Boeing has submitted comments indicating that it is concerned about potential interference to its 2 GHz downlinks (specifically, from the ATC BS and MT transmitters to Boeing's MSS aircraft receiver). As mentioned previously these scenarios are actually out-of-band sharing situations, because each MSS system **will** be assigned its own home spectrum.

The next two sections compare the Boeing downlink interference calculations which were performed using the OOB values contained in the initial ICO proposal with a similar calculation using ICO's latest

[23] *See* App. C2, § 1.3.

out-of-band values at the band edge. These calculations consider potential interference to a Boeing receiver while the aircraft is on the ground at an airport. The final value calculated is the distance between the ICO transmitter and the aircraft on which the Boeing receiver is mounted. Boeing used an interference criterion of a 6% increase in the receiver noise floor. While there is no regulation that codifies a 6% terrestrial receiver noise increase as being harmful interference, it is used in this case. to gauge the interference potential.

2.2.2 Potential Interference to Boeing Airborne Receivers from ATC Base stations
Table 2.2.2.A reproduces the Boeing calculations in the third column from the left. This linkanalysis. assumes that the out-of-band emission from an ICO ATC base station is –56.5 dBW/4 kHz. ICO has stated that it will limit emissions at the band edge to –100.6 dBW/4 kHz for **BS.** The Boeing analysis indicated that a separation distance of some 21.9 km would be required between the ATC base station and the airborne Boeing receiver for the interference level to produce an increase of 6% in the receiver noise floor or less. Use of the ICO band-edge values reduces this required separation distance to 0.19 km (630 ft). For normal in-flight operations an aircraft-to-base station separation distance of 0.19 km would be considered to be sufficient to ensure that no interference would occur. This **is** particularly true because the selected interference criterion of an increase in effective receiver noise temperature of 6% would not cause a serious degradation in the performance of the Boeing **MSS** system. However, the possibility exists that a base station could be placed near an airport. In this situation care will have to be exercised to ensure that the base station is located at least 630 feet from a runway area or **an** area in which an aircraft may be parked or taxing.

Table **2.2.2.A** - Interference to Aircraft Terminal from ATC **Base** Station

Parameters	Units	**Boeing Analysis**	**Staff Analysis**
Frequency	(GHz)	2.0	2.0
Area of Isotope	(dBm^2)	-27.5	-27.5
Noise Temperature	(K)	200	200
Noise Density (No)	(dBW/Hz)	-205.6	-205.6
Interference Criteria Io/No	(dB)	-12.2	-12.2
Number of ICO Transmitters	(#)	1	2
Interference Density (Io)	(dBW/Hz)	-217.8	-217.8
Base Station OOB, Boeing Value	(dBW/4 kHz)	-56.5	
ICO Supplied OOB Value	(dBW/4 kHz)		-100.6
Transmitter OOB Emission	(dBW/Hz)	-92.5	-136.6
Antenna Gain (Boeing User Terminal)	(dBi)	0.0	0.0
Polarization Isolation	(dB)	0.0	0.0
Required Propagation Loss	(dB)	-125.3	-84.2
Required Separation Range	(km)	21.9	0.19
Required Separation Range	(ft)	71.800	630

2.2.3 Potential Interference to Aircraft Receivers **from** ATC MT
Boeing also commented that. based upon the OOB values contained in the ICO application. the emission from 6 ATC MTs could increase the noise floor of the aircraft receiver by 6% if the MTs where all located at a disrance of 0.8 km from the aircraft. Table 7.2.3.A. below, shows both the Boeing calculation and our calculation assuming ATC MTs are restricted to the band-edge values supplied in the ICO *ex parte* letter. The required separation distance is reduced to 0.03 km (105 ft) for the ATC MT and 0.02 **km**

(56 ft) for MSS user terminals. The probability of having 6 simultaneously transmitting MTs within 100 feet of an aircraft is small. This is particularly true because MTs in the terminal building would experience building blockage and MTs on the airport tarmac should be operated only by airport personnel. Again. the selected interference criteria of an increase in noise temperature of 6% would not cause significant interference to the Boeing system under transient conditions and this situation should not cause a problem for the Boeing MSS receiver.

Table 2.23.A - Interference to Aircraft Terminals from ATC MTs

Parameters	Units	Boeing Analysis	ICO MT	ICO MES
Frequency	(GHz)	2.0	2.0	2.0
Area of Isotope	(dBm^2)	-27.5	-27.5	-27.5
Noise Temperature	(K)	200	200	200
Noise Density (No)	(dBW/Hz)	-205.6	-205.6	-205.6
Interference Criteria Io/No	(dB)	-12.2	-12.2	-12.2
Number of Mobile Transmitters	(#)	6	6	6
Acceptable Io (6% noise increase)	(dBW/Hz)	-217.8	-217.8	-217.8
Polarization Isolation	(dB)	0.0	1.4	0.0
Boeing Value for OOB Emission	(dBW/4 kHz)	-93.5		
ICO OOB **Value**	(dBW/4 kHz)		-119.6	-126.5[24]
Number of Transmitters	(dB)	7.8	7.8	7.8
Out-of-Band Emission Level	(dBW/Hz)	-121.7	-147.8	-154.7
Antenna Gain (Boeing UT)	(dBi)	0.0	0.0	0.0
Required Prop Loss	(dB)	-96.1	-63.1	-63.1
Required Separation Range	(Km)	**0.8**	0.03	0.02
Required Separation Range	(feet)	24851	104	56

2.2.4 Saturation of Boeing MSS Receivers

Boeing has expressed concern[25] over **the** possibility of both ICO MTs and BSs saturating a Boeing MSS receiver. The Commission's 2 GHz MSS rules require that the MSS transceiver be capable of tuning across at least 70% of the United States 2 GHz MSS allocation.[26] Boeing explains that the **MSS** receiver needs to tune across the entire available *2* GHz downlink band. This leaves the **front** end of the Boeing receiver open to the full power of transmitters from the ICO ATC system. Boeing specifically states that it is using **a** receiver designed to saturate at -80 dBW, or -50 dBm.

2.2.4.1 Saturation of Boeing MSS Receivers from ICO ATC MT

The possibility of ICO ATC MT interfering **with.** or saturating, Boeing MES receivers can only occur in ICO Reverse-Band or Downlink-Hybrid Modes. Boeing's analysis of ATC MT[27] is reflected in Table

[24] *Out-of-band* emission from **an** ICO MSS terminals are identified in 47 C.F.R.§ 25.202(f).

[25] Boeing Supplemental Comments at 10.

[26] *See* 47 C.F.R § 25.143(b)(2)(ii)(2001)

[27] *See* Boeing **April** 5, *2002 Ex Parte* Letter at 11

2.2.4.1.A below. The analysis indicates that the Boeing MSS receiver will experience saturation if it is within 96 feet of an IC0 ATC MT and clearly visible to the MT. It should be noted that our analysis assumes an MT EIRP of one watt, while Boeing assumed -10 dBW.

Table 2.2.4.1.A Saturation of Boeing receivers from ATC MTs

Parameters	Units	Value
Frequency	(GHz)	**2.185**
Transmit Power	(dBW)	0.0
Boeing Receiver Saturation Power	(dBW)	-80.0
Polarization Isolation	(dB)	1.4
Antenna Gain	(dBi)	0.0
Required Propagation Loss	(dB)	78.6
Required Separation Distance	(m)	93
Required Separation Distance	(ft)	305

While Boeing's MSS receivers will be located on aircraft, the same can not be said of **all** of the other potential *2* GHz **MSS** licensees. Additionally. as we said earlier we would assume a saturation level of -60 dBm unless one of the parties. like Boeing, specifically stated that it was using a receiver with more robust saturation characteristics. If the saturation level of -60 dBm is used, a calculation similar to that of Table 2.2.4.1.A yields a required separation distance of 295 meters or 970 feet. While Boeing states that "it is exploring the possibility of making modifications *to* its receivers." there is no assurance that other MSS licensees will do the same.

ICO responds to Boeing by stating that it "believe[s] that with an appropriate selection of "off-the-shelf" receiver components and a prudent design, saturation levels on the order of -55 dBW *to* -50 dBW are achievable for any MSS [**MES**]."[28] These levels are equivalent to *-25* dBm and -20 dBm respectively. There is no technical information presented in the record to support **ICO's** claim and it would be unreasonable to require all MSS licensees to design to these saturation levels at this time. IC0 additionally indicates that factors such as voice activation and power control will reduce the effect of saturation on MES receivers. These factors are taken into account when large quantities of ATC MTs are being considered. In this case the saturation is caused by a single MT and these factors can not be used to mitigate the potential interference in this situation.

2.2.4.2 Saturation of Boeing MSS Receivers from ICO ATC BSs

Boeing provides an analysis of the potential for saturation of its MSS receivers from ICO BS transmitters" and comes to the conclusion that saturation is possible when the base station is within about 2 km[30] of the MSS receiver. The Boeing analysis assumes mainbeam coupling of the BS antenna and an airborne MSS receiver. The distance at which the receiver will receive sufficient power to undergo saturation will depend upon a number of factors such as the actual BS antenna pattern. the height of the BS tower and the presence or absence of intervening structures. Recommendation ITU-R F.1336

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[28] *See* ICO April 10. 2002 *Ex Parte* Letter, Attach. C.

[19] *See* Boeing **April** 5. 2002 *Ex Parte* Letter at 12.

[30] The precise number calculated by Boeing war 2.068 km.

provides a reference antenna pattern that can be used near the mainbeam of the BS transmitter. If the Boeing MSS receiver is assumed to be mounted on the top of an aircraft (7.5 m off the ground) and the ATC BS tower is 30 meters high. then the distance at which the receiver saturates will depend on the tilt angle of the **BS** antenna. Table 2.2.4.2.A shows the distance at which saturation would occur for a ***-2.5*** degree downtilt of the BS antenna.

Table 2.2.4.2.A shows that the power flux of -51.8dBW/m^2 is equivalent to the Boeing Saturation level of -50 dBm. The lower part **of** the Table shows the distance required for the power flux from the ATC base station to drop-off to -51.8 dBW/m^2. For a BS antenna tilt of -2.5 degrees, the tilt angle proposed by ICO, the power **flux** will be at -51.8 dBW/m^2 approximately 1126 m from the antenna.

Table 2.2.4.2.A Calculation of Necessary Separation Distance for a Boeing **MSS Receiver and ICO BS**

Parameters	Units	Value
Frequency	(GHz)	**2.185**
Assumed Saturation level	(dBm)	*-50*
Conversion to dBW	(dBm)	-30
Assumed Saturation level	(dBW)	-80
Receive Antenna Gain	(dBi)	0
Isotropic Antenna Area	(dBm^2)	*-28.2*
Power **Flux** at Saturation	(dBW/m^2)	-51.8
Base Station Height	(m)	**30**
MSS Terminals Height	(m)	7.5
BS Tilt Angle	(Degrees)	*-2.5*
BS Off-Boresight Angle	(Degrees)	1.36
Mainbeam EIRP	(dBW)	*21*
BS Antenna Discrimination	(dB)	-6.8
EIRP towards MSS Receiver	(dBW)	20.2
Range to MSS Receiver	(m)	1126
Path Loss	(dB/ m^2)	-72.0
Power **Flux** at Boeing Receiver	(dBW/m^2)	-51.8

Performing the same calculation for a "hand held" MSS receiver with a more typical saturation level of -60 dBm produces the calculations shown in Table 2.2.4.2.B. In this case the **MSS** receiver is 1.5 m high while the BS antenna is modeled as king 30 m high. The separation distance for the BS antenna tilt angle of -2.5 degrees is over 2 km.

Table 2.2.4.2.B Calculation of Necessary Separation Distance for Typical Handheld MSS Receiver

Parameters	Units	Value
Frequency	(GHz)	2.185
Assumed Saturation level	(dBm)	-60
Conversion dBm to dBW	(dBm)	-30
Assumed Saturation level	(dBW)	-90
Receive Antenna Gain	(dBi)	0
Isotropic Antenna Area	(dBm^2)	-28.2
Power Flux at Saturation	(dBW/m^2)	-61.8
Base Station Height	(m)	30
MSS Terminals Height	(m)	1.5
BS Tilt Angle	(Degrees)	-2.5
BS Off-Boresight Angle	(Degrees)	1.7
Mainbeam EIRP	(dBW)	27
BS Antenna Discrimination	(dB)	-11.2
EIRP towards MSS Receiver	(dBW)	15.8
Range to MSS Receiver	(m)	2148
Path Loss	(dB/m^2)	-77.6
Power Flux at MSS Receiver	(dBW/m^2)	-61.8

We agree with Boeing that, in areas in which free-space propagation is the dominant mode of propagation, the ATC BS should observe a separation distance to protect MSS receivers from possible saturation. For a -2.5 degree BS antenna tilt, the separation distance would be about *2* km. Alternately. the BS could be implemented in a way to reduce the area in which the power **flux** is greater than -61.8 dBW/m^2.

In many urban areas free-space propagation will not be the dominant mode of propagation. Some parties to this proceeding have used free-space loss to determine the expected attenuation from the ATC BS to a MES. Others have used the Walfisch-Ikegami (WI) propagation model which typically results in a higher attenuation for the same case. The WI model is based upon the expected propagation loss in an urban/city setting that consists of relatively tall buildings. The National Institute of Standards and Technology (NIST) has developed a computer program that compares a number of different propagation models including the WI model. Using the NIST software.[31] propagation loss values for a 1 **km** path of 136.4 dB are calculated from the Hata-city model. **131.4** dB from the CCIR (now ITU-R) model and 171.7 dB is calculated from the WI non-LOS model. All of these predicted losses are well above the 105.2 dB total free space losses[32] resulting from Tables 2.2.4.2.A and Table 2.2.4.2.B. Based upon the values calculated by the NIST software, sufficient loss appears to be available in urban settings to prevent the saturation of MSS receivers in these environments.

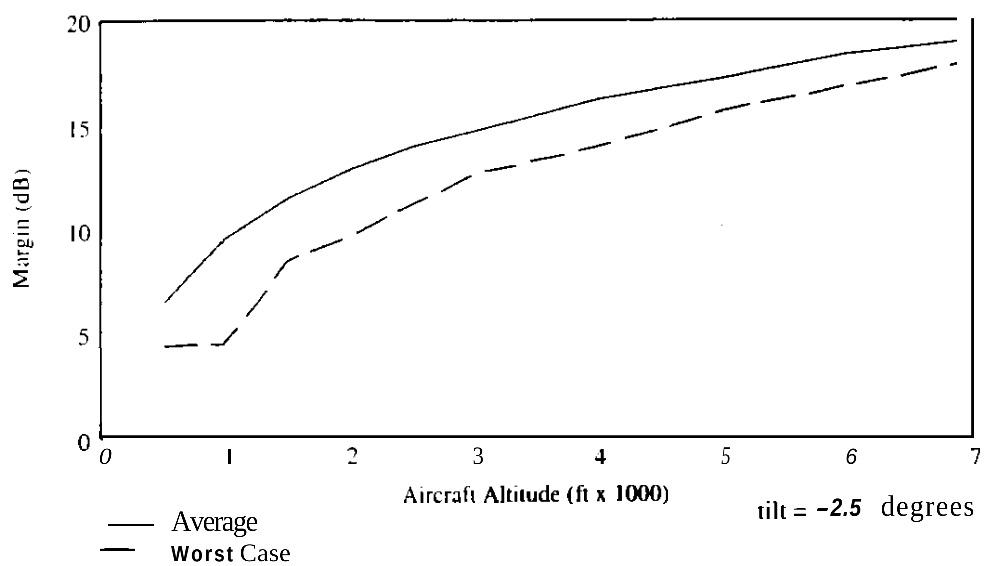
[31] *See* National Institute of Standards and Technology. Wireless Communications Technology Group, *General Purpose Calculator for Outdoor Propagation Loss. available at* <http://w3.antd.nist.gov/wctg/manet/prd_propcalc.html> (last visited. Jan. 30, 2003) (offering propagation software).

[32] In Tables 2.2.4.2.A and 2.2.4.2.B the free space loss is the sum of the path loss and the isotropic antenna area

2.2.4.3 Potential Saturation of Airborne 2 GHz receivers

A potential problem discussed by the parties at L-band is the possibility of the saturation of an airborne MSS receiver from multiple BS transmitters. This same problem could potentially occur at 2 GHz between the Boeing **MSS** and the ICO BSs because the Boeing **MSS** receivers, like the L-band Inmarsat receivers. are utilized on board aircraft. A MathCad model was written to analyze this situation. The model is included as Attachment 1 to this Appendix. The model randomly distributes a number of base stations across the area visible to an aircrafi at a given height. The base stations, assumed to be on thirty-meter towers, use antennas with mainbeam patterns based upon Recommendation ITU-R F.1336. The antenna roll-off is continued to 25 dB down from the mainbeam gain to represent the antennas that ICO has stated it will use. The mainbeam EIRP of each BS is *27* dBW. The MSS receiver is conservatively assumed to have a gain of 0 dBi toward all of the BSs. The total cumulative power received at the **MSS** terminal is calculated based upon the random distribution of a population of **1000 BS** transmitters. This total received power is compared with Boeing's -50 dBm saturation level and the difference between the total received power and the saturation level is used to calculate a saturation margin. **If** the margin is positive, the MSS receiver is receiving an interfering signal power level insufficient to cause saturation. The program **runs** 100 trials of 1000 randomly placed BS and plots both the average margin over the 100 trials and the single worst case margin. Figure 2.2.4.3.A shows the average and worst case margins as a function of the aircraft altitude for a BS tilt angle of -2.5 degrees.

Figure 2.2.43.A Modeled Average and Worst Case Saturation Margin for Boeing Airborne MSS Terminal



As presented in Figure 2.2.4.3.A the worst case margin. shown as a dashed line, is always positive indicating that the Boeing MSS receiver would not saturate. The results of this analysis indicate that a relatively large deployment of ATC base stations would nor cause Boeing's airborne MSS receivers to saturate while airborne and the potential for this type of interference is low.

3.0 Inter-Service (Adjacent Allocation) Interference Analyses

The 2 GHz Report and Order adopted service rules to protect services in the frequency bands adjacent to the 2 MSS bands from MSS operations. The following examines the effect of the addition of MSS ATC MT and BS transmitters in the MSS bands upon services in the adjacent allocations.

3.1 Analysis of Bands Adjacent to MSS Uplink Band *(1990-2025 MHz)*

Lower Adjacent Band (1710-1990 MHz). The frequency band 1710-1990 MHz is adjacent to the MSS uplink band. This band was auctioned for use by Broadband PCS systems. The out-of-band emission limits that ICO proposed to meet are those of a PCS system (i.e., Pan 24.238), specifically -67.0 dBW/4 kHz.[33] CTIA[34] and certain incumbent PCS licensees and PCS equipment manufacturers have raised the issue of possible out-of-band emissions interference from 2 GHz ATC MTs into PCS mobile receivers operating in the 1930-1990 MHz band. which might not be adequately protected against by adopting our current limitations for PCS mobile transmitters.[35] CTIA suggests that this potential for interference could be mitigated by providing 15-20 MHz of frequency separation between the PCS bands and ATC operations. While we agree with CTIA that this potential for interference exists. we find that amount of frequency separation required between ATC mobile terminals operating under the proposed ATC limits and existing PCS mobile terminals would render unusable a significant portion of the frequency above 1990 MHz, and thus would be inadvisable. The compliance with a more stringent out-of-band emissions limitation, coupled with reallocation of the 1990-2000 MHz band to other uses, would mitigate the potential for interference while maintaining the usefulness of spectrum immediately adjacent lo the 1930-1990 MHz PCS band. The 1980-2010 MHz band has been allocated for MSS use since the 1992 World Administrative Radio Conference. Since at least 1994, we have been aware of the potential for some level of interference between MSS and PCS systems.[36] PCS carriers similarly were aware of potential interference from MSS systems in adjacent spectrum. and could have taken this into account in the design of their equipment. But the likelihood of potential interference from future MSS operations was generally considered minimal due to the fact that MSS systems were expected to operate primarily in rural and/or remote environments, and in such areas the probability of an MSS handset operating close enough to a PCS handset to cause interference was low. However, ATC may pose a greater interference problem for adjacent PCS operations because of the likelihood that ATC handsets will operate in the identical environments in which PCS handset operate (e.g., in urban areas. indoors. etc.). and that in such environments ATC handsets could be close enough to PCS handsets to cause interference. Therefore, some additional requirements on ATC handsets may be necessary.

Certain incumbent wireless carriers assert that there exists the potential for ATC mobile terminals to cause desensitization or receiver overload to PCS mobile receivers operating below 1990 MHz.[37] We do not believe that the problem of desensitization and overload is as severe as these parties contend. First,

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[33] *See* ICO April 10. 2002 *Ex Pane* Letter at 2

[34] Letter from Dianne Cornell, Counsel, Cellular Telecommunications and Internet Association to Marlene H Dortch, Secretary. Federal Communications Commission. IB Docket No. 01-185 at 2-7 (filed Jan. 15. 2003).

[35] *See* 47 C.F.R.§ 24.238(a).

[36] *See Amendment of the Commission's Rides to Establish New Personal Communications Services*. Third Memorandum Opinion and Order. 9 FCC Rcd 6908, 6922-23. ¶¶ 83-87 (1994).

[37] *See* CTIA Jan. 14, 2003 *Ex Parte* Letter at 5-6

we believe that the parties may have assumed that the only interference rejection capability of an existing PCS mobile receiver is from the front-end band pass filter of the receiver. This does not take into account other factors such as additional filtering from the intermediate frequency (IF) circuitry. Additionally, the parties' assertions that receiver desensitization or overload interference will occur appear to be based on what would be considered worst-case circumstances (e.g., that ATC and PCS handsets are operating in close proximity under line-of-sight conditions, that ATC handsets are operating at full power. and that the antennas of the handsets are aligned for perfect coupling). The probability of these various circumstances occurring simultaneously is relatively small. We thus believe that, while the potential for PCS receiver desensitization or overload from ATC operations exists, it is less than suggested by the commenting parties. We also believe that interference problems that may develop over time as ATC is deployed can be mitigated by future PCS handset design modifications and through a cooperative effort by PCS and MSS ATC licensees to resolve these issues.[38]

Upper Adjacent Band (2025-2110 MHz). The frequency band directly adjacent to the upper portion of the **MSS** uplink band **(2025-2110 MHz)** is occupied by Broadcast Auxiliary and Electronic News Gathering (BAS/ENG) services. Additionally, it is used by NASA for Earth-to-space transmissions in the space operations service. The Society of Broadcast Engineers (SBE) in its comments expressed a number of concerns including:[39]

(1) ATC might provide interference to urban TV BAS systems; in particular, the ATC base station transmitter operating in the ICO Uplink Hybrid or Reverse Band Mode could cause saturation of the receive-only ENG sires:
(2) The two ICO ATC duplex modes might be infeasible because of the stringent duplexer requirements; and
(3) ICO's ATC link budgets might contain errors, based upon SBE's conjecture that the ICO user terminal would use a single antenna for both the satellite and ATC links.

The SBE stated that "Filling that reallocated spectrum with low power, mobile MSS telephones will pose little or no risk of brute force overload (BFO) to 2 GHz TV BAS receivers."[40] But, SBE adds, "if terrestrial [ATC] cell sites will be allowed . . . . [T]he Commission would be placing high powered stations with EIRPs of up to 1,610 watts, or 62.1 dBm, immediately adjacent to systems with receiver sensitivities of around -87 dBm." And "[a]n MSS terrestrial station should not be allowed where it would result in a receive carrier level (RCL) in excess of -30 dBm" because of possible BFO of the ENG receiver."[41] Even if the power (*i.e.*, EIRP) of the ATC base station is 501 Watts (27 dBW) as mentioned in

[38] We note that. as a practical matter, there will be some period of time before ATC is deployed and a longer period before it has the potential to reach market penerration levels that could materially affect the likelihood of interference. We also note that the Spectrum Policy Task Force report encourages the use of voluntary receiver performance requirements to address these types of problems See Spectrum Policy Task Force Report at 31

[39] SBE Comments at 16-17

[40] SBE refers to "brute force overload." This term and "receiver saturation" are used to mean the same thing in this Appendix.

[41] SBE Comments at 20.

the ICO proposal,[42] SBE indicated that the separation distance between the ATC base station and the ENG receiver would have to be 2.6 km. assuming mainbeam-to-mainbeam coupling.[43]

The SBE calculations dealing with the pointable ENG antennas are correct. While the ICO ATC proposal did evaluate lower powered 27 dBW EIRP base stations, these transmitters could cause interference to the receive-only ENG installations. For this reason it would be necessary for ATC BS transmitters operating near the 1990 MHz band to be coordinated with existing ENG systems.

SBE also claims that in both of the ICO duplexed modes, the frequency separation between the ATC transmit and receive channels only can be, at most, 35 MHz (*i.e.*, the width of the *2* GHz **MSS** allocation). SBE bases its argument on the 18 MHz bandwidth of the phase I - *2* GHz MSS spectrum and not the entire allocation. SBE indicates that at 890 MHz, the frequency separation between the two sides of the PCS link is **45** MHz or (45/890*100 =) 5.0%, while at *2* GHz the frequency separation will be only (35/1990*100 =) 1.8%. ICO responded to the SBE comments on duplexers by pointing out that technology has progressed to the point where ICO estimates that only 15 to 20 MHz is currently required at *2* GHz.[44] The example that ICO quotes is the European E-TAC system. an analog. first generation, PCS system. that uses a frequency separation of (12/890*100 = 1.3%). This would be equivalent to 27 MHz separation at 2 GHz.

The final SBE comment assumed that ICO would use a single antenna on the user terminal for both the satellite and ATC operations. ICO indicated that it would be using separate antennas for the ATC mode and MSS mode in its handset.[45]

*Space **Operations Service** (2025-2110 MHz).* The ITU has approved several Recommendations dealing with the Space Operations service. Recommendation ITU-R SA.1154 "Provisions To Protect The Space Research (SR). Space Operations (SO) and Eanh-Exploration Satellite Services (EES) and to Facilitate Sharing With The Mobile Service in the 2025-2110 MHz and 2200-2290 MHz Bands" provides detailed information on the characteristics of the space systems and contains a study of the potential interference from 3G systems to satellite receivers. While, this study is directed at co-frequency band sharing. it can also be used to evaluate the ATC out-of-channel situation. Table 2 of Annex 1 of the Recommendation contains a number of columns, each of which calculates the interference margin from a different type of mobile transmitter. Column I, for example. starts with a 3G user terminal that transmits -72.2 dBW/Hz and concludes that all of the mobile terminals in view of a 250 km altitude satellite will produce an interference level 16.0 dB above the selected interference criteria. Using the Commission's Pan 24 emission roll-off, the ATC out-of-channel emission is -67.0 dBW/4kHz, or -103.0 dBW/Hz. Assuming the same conservative assumptions that are inherent in Recommendation **ITU-R** SA. 1154. the ATC MTs would produce an interference margin of (16.0-(103.0-72.2) =) -14.8 dB. This is a received interference power level that is 14.8 dB below the interference criteria.

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[42] ***See*** ICO Mar, 8,2001 *Ex **Pane*** Letter, App. B at 11

[43] **The** SBE also quotes fixed sites with 45 dBi antennas (this requires an approximately 11 meter, or 38 fool. diameter antenna ai 1990 MHz). The beam-width of this antenna would he about 0.9 degrees which is actually smaller than is normally used in designing fixed microwave links. Thia system will not he analyzed.

[44] ICO Reply. App. C at 2

[45] ICO Reply. App. C at 3

With respect to base stations, the fifth column of the Table contained in Recommendation ITU-R SA.1154 analyzes 3G base stations that emit –44.0 dBW/Hz and concludes that they will produce an interference level 34.6 dB above the protection criteria. The ATC base station out-of-channel emission provided by ICO, using Pan **24** rules, is –67.0 dBW/4 kHz, or –103.0dBW/Hz. This is 59 dB below the power level assumed in the Table and therefore 24 dB below the stated protection criteria. This calculation does not take into account the 25 dB suppressed upward antenna gain component that IC0 indicates it will use **and** it assumes that there are **2.4** million active base stations in view of the low-orbit satellite. There should be no interference experienced by the adjacent band space operation systems according to our assessment.

3.2 Analysis of Bands Adjacent to MSS Downlink Band (2165-2200 MHz)

Analysis of Lower Adjacent Band (2110 - 2165 MHz). At the 1992 World Administrative Radiocommunication Conference (WARC-92). the 2110-2200 MHz band was identified for use by countries to implement future public land mobile telecommunication systems, i.e., ***3G*** systems.[46] WARC-92 noted, however, that such use does not preclude the use of these bands for other allocated uses. The FCC has since identified the 2110-2200 MHz band, including the band immediately adjacent to the lower edge of the MSS downlink, for reallocation from the fixed service for new emerging technologies. Portions of this band, i.e., 2165-2200 MHz, have been licensed to MSS systems. If the remaining band below 2165 MHz is assigned to ***3G*** systems then the MSS ATC assignment will be adjacent to other commercial 3G systems. In this event there should be no harmful interference between the systems. The current occupants of the 2110-2165 MHz band include both digital and analog fixed systems. These systems are described in the TIA publication. TSB 86 "Criteria and Methodology to Assess Interference between Systems in the Fixed Service and the Mobile-Satellite Service in the Band 2165-2200 MHz". The following table, Table 3.2.A, analyzes the ICO maximum out-of-band values listed in Table 1.1.B to determine the potential for impact to analog systems operating below 2165 MHz.

The fixed service utilizes two interference criteria, typically, a long term interference criteria of 20 pW0p[47] per hop that should not be exceeded for more than 20% of the time and a higher level, short term interference criteria that should not be exceeded for a very short percentage of time.[48] Table **3.2.A** presents an interference link budget for the transmitters mentioned in the **ICO ex *parte*.** The model represented by this Table places the ATC BS and MT transmitters 20 feet from the fixed system receive antenna and in the main-beam of the receive antenna. While this is a physical impossibility for a fixed system mounted on a rower, it serves as a very conservative worst case situation. For the two IC0 transmitters, the smallest margin with respect to the fixed service "long term interference criteria" is greater than 18 dB. This occurs for the IC0 ATC BS transmitter. The largest margin, 37.8 dB, occurs for the ATC MT transmitter. Since the shon term interference criteria are significantly higher than the long term crireria, the interference margin will be higher when dealing with short term interference.

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[46] *See* ***Spectrum*** *Study of the 2500-2690 MHz* ***Band****: The* ***Potential for Accommodating Third Generation Mobile*** *Systems*, Interim Report, **9** (rel., Nov. 15, 2000). *available at* <http://www.fcc.gov/3G/3G_interim_report.pdf> (last visited, Feb. 4, ***2003) (Interim Report*** *on the Spectrum Study of the 2500-2690 MHz Band).*

[47] The term "pW0p" stands for psophometrically weighted picoWatts – a measurement **that** relates to frequency division multiplexed (FDM) voice circuits.

[48] *See* TIA Telecommunications Bulletin TSB 86, ***Criteria*** *and* ***Methodology to Assess*** *Interference Between Systems in the* ***Fired*** *Service and the Mobile-Satellite Service in the Band 2165-2200 MHz*, § 3.2.1

In addition to analog fixed systems. this frequency band also contains digital point-to-point system. According to TIA "[n]o specific numerical interference criteria have been developed in either the TIA or the ITU-R to specifically address short term interference into digital receivers."[49] Because of the large interference margins calculated for analog systems. the **ATC** out-of-band emission should pose no unacceptable interference to either the analog or digital fixed systems operating below 2165 MHz.

Table 3.2.A – Analysis of Potential Interference to Analog Systems below 2165 MHz

Parameter	Units	Base Station	Mobile Terminals
Frequency	(GHz)	2.165	2.165
Range	(ft)	20	20
ATC Transmitter Power	(dBW/4kHz)	- 100.6	-119.6
ATC Antenna Discrimination	(dB)	0.0	0.0
Polarization Loss	(dB)	0.0	0.0
Free Space Loss	(dB/m^2)	-26.7	-26.7
Receive Antenna Mainbeam Gain	(dBi)	32.2	32.2
Area of Isotropic Antenna	(dBm^2)	-28.2	-28.2
Received Power	(dBW/4kHz)	-123.2	-142.2
Psophometer Weighting Factor[50]	(dB)		2.5
Received Power	(dB(pW0W/4kHz)	-125.7	-144.7
Power Ratio dB(W/pW)	(dB)	120.0	120.0
Received Power dB(pW0p)	(dB(pW0p))	-5.7	-24.7
Long Term Criteria[51]	(pW0p)	20.0	20.0
Long Term Criteria	(dB(pW0p))	13.0	13.0
Long Term Margin	(dB)	18.8	37.8

Analysis of Upper Adjacent Band (2200 – 2290 MHz). Of the four ATC Modes considered in the ICO proposal. the Downlink Hybrid and Forward Band Mode would place BS adjacent to the 2200-2290 MHz band, while the Downlink Hybrid and Reverse Band Modes would place MTs adjacent to the 2200-2290 MHz band. The band 2200-2290 MHz is used by the United States Government for satellite-to-earth communications. Typical space research receivers use large tracking antennas located on controlled government facilities. However other installations such as universities and private companies may also make use of space research or space operations receivers under certain conditions. Recommendation ITU-R SA.1154 contains interference criteria for both space operations and space research systems that utilize the 2200-2290 MHz band as shown in Table 3.2.B.

[49] *Id.* at 19.

[50] Bell Telephone Laboratories, Inc., *Transmission Systems for Communications*, 175 (4th ed. rev., 1971).

[51] TIA Telecommunications Bulletin TSB 86. *Criteria and Methodology to Assess Interference Between Systems in the Fixed Service and the Mobile-Satellite Service in the Band 2165-2200 MHz*, § 3.2.1

Table 3.2.B Interference Protection Parameters for Space Research and Space Operation Services

Parameter	Units	Space Operations	Space Research
Minimum Elevation Angle	(Degrees)	3.0	5.0
Maximum Interference Level	(dBW)	-184.0	-216.0
Reference Bandwidth	(Hz)	1000	1
Assumed Antenna Gain[52]	(dBi)	20.1	14.5
Bandwidth Conversion	(dB)	30.0	0.0
Normalized Interference Limit	(dBW/Hz)	-234.1	-230.5

SR/SO Earth Stations	Units	ATC BS	ATC AT
Frequency	(GHz)	2.2	*2.2*
Range	(km)	0.82	0.09
ATC Transmitter Out-of-Band Power	(dBW/4kHz)	-100.6	-119.6
Bandwidth Ratio	(dB)	36.0	36.0
ATC Emission	(dBW/Hz)	-136.6	-155.6
Propagation Loss	(dB/m^2)	-97.5	-78.5
Interference Power	(dBW/Hz)	-234.1	-234.1
Normalized Interference Level	(dBW/Hz)	-234.1	-234.1
Margin	(dB)	0.0	0.0

Table 3.2.C shows that a separation distance of 820 m is required to protect the space operations receiver from an ATC BS. *If* the ATC system is limited to the Forward Link mode of operations there would be no MTs adjacent to the 2200-2290 MHz band. The BS would have to be within 0.82 km, or 0.5 miles, of the space operations receiver to cause interference. This distance should be within the controlled area of

[52] The pain is calculated from $G(\Theta) = 32-25*\log(\Theta)$ dB, where Θ is the minimum elevation angle

many United States Earth station facilities. If a space operations eanh station is associated with a non-controlled area, the pointing direction of the earth station antenna would become important in determining whether or not interference would occur. If the antenna is pointed 10 degrees away from the mobile **ATC** MT, instead of the assumed **3** degrees, the antenna discrimination would increase by another 13 dB.

The operator should contact the Commission at the rime of licensing for a list of Government **and** commercial eanh stations using the 2200-2290 MHz band.

Annex 1 to Appendix C1

MathCad Program for Evaluating Potential Saturation of Airborne **MSS** Receivers at **2 GHz**

The following is a look at an airborne receiver getting potential interference from a number of ATC base stations. The base stations are distributed randomly over the area visible to the aircraft. The airborne receiver has an omnidirectional antenna. The base station has a G2 antenna which is oriented with a angle of "tilt" to the horizon.

________________________________ some necessary functions

$dB(x) := 10\cdot\log(x)$ $\quad$ $r2d := \frac{180}{\pi}$ $\quad$ $d2r := \frac{4}{180}$

$real(x) := 10^{\left(\frac{x}{10}\right)}$

$freq := \frac{(2.165 + 2.200)}{2}$ $\quad$ $iso := dB\left[\frac{\left(\frac{0.3}{freq}\right)^2}{4\cdot\pi}\right]$ $\quad$ $iso = -28.229$

$freq = 2.183$

model parameters________________________

function atan2(x,y) returns the angle (0 to 360 degrees in radians) given x and y values

$$atan2(x,y) := \begin{array}{|l} ans \leftarrow \frac{x}{2}\cdot sign(x) \text{ if } y = 0 \\ ans \leftarrow atan\left(\frac{x}{y}\right) \text{ otherwise} \\ ans \leftarrow \pi + ans \text{ if } y < 0 \\ ans \leftarrow 2\cdot\pi + ans \text{ if } x < 0 \wedge y > 0 \\ ans \end{array}$$

$$\text{spread\_cir}(num, dist) := \left| \begin{array}{l} i \leftarrow 0 \\ \text{while } i \le num \\ \quad \left| \begin{array}{l} xa \leftarrow (1.0 - \text{rnd}(2.0)) \cdot dist \\ ya \leftarrow (1.0 - \text{rnd}(2.0)) \cdot dist \\ da \leftarrow \sqrt{ya^2 + xa^2} \\ \text{if } da \le dist \\ \quad \left| \begin{array}{l} az \leftarrow \text{atan2}(xa, ya) \\ out_{i,0} \leftarrow az \\ out_{i,1} \leftarrow da \\ i \leftarrow i + 1 \end{array} \right. \end{array} \right. \\ out \end{array} \right.$$

Function spread-cir generates random points over a circularly shaped area and returns the distance and azimuth of the point from a central point. Distance is returned in the input units of the argument 'dist'. Az is returned in radians. 'Num" is the number of required randomly located points. This function requires the 'atan2(x,y)' function. The returned array 'spread-cir' is a two column array. The first column (subcript n,0) is the azimuth. The second (subscript n,1) is the distance. The variable 'n;' is the running index.

Electrical parameters

Base station parameters

$Po := 10$ Base station power in dBW

Base Station Gain discrimination

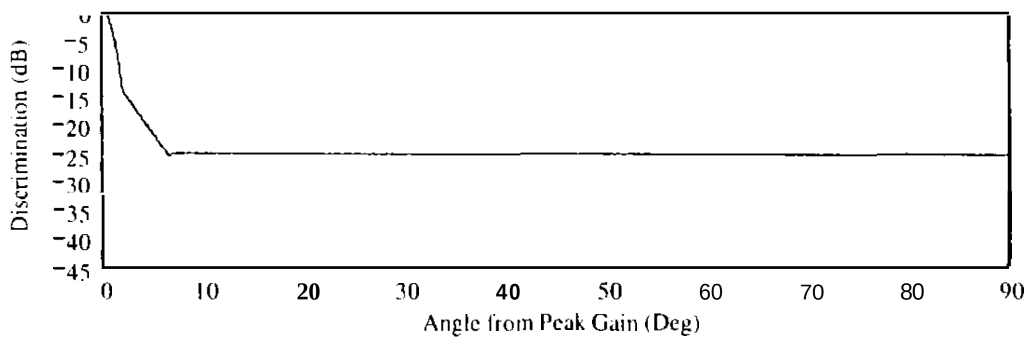
$Go := 17$ parameter used in defining antenna discrimination pattern, main beam gain = **17** dBi alter ICO Application.

$$\theta 3 := 107.6 \cdot 10^{(-0.1 \cdot Go)}$$

$$\text{Gbs2}(\theta) := \left| \begin{array}{l} g \leftarrow -Go \cdot \left(\frac{|\theta|}{\theta 3} \right)^2 \quad \text{if } 0 \le |\theta| < 1.935 \\ g \leftarrow -(|\theta| - 4) \cdot 2.5 - 19 \quad \text{if } 1.935 \le |\theta| < 6.4 \\ g \leftarrow -25 \quad \text{otherwise} \\ g \end{array} \right.$$

Note: The antenna pattern is based on a combination of ITU-R Rec. 1336 near the mainbeam and a roll-off to a discrimination of 25 dB.

$\theta := 0..900$



tilt := −2.5	Tilt angle of base station antenna
EIRP := Po + Go	Base station mainbeam EIRP
EIRPm := EIRP + 30	Base station EIRP in dBm

Aircraft Gain Patterns

$\mathrm{Gac}(\phi) := 0$	Omnidirectional constant gain from Boeing
limit := −50	Receiver Saturation Level in dBm from Boeing

Geometric constants and parameters

Re := 6378·1000	Earth radius meters
hbs := 30	height of base station antenna in meters
hac_ft := 500	height of aircraft in ft

$$hac := \frac{hac\_ft}{5280} \cdot 1.609 \cdot 1000$$ $hac = 152.367$ height of aircraft meters

$$\zeta := acos\left(\frac{Re}{(Re + hbs)}\right)$$ Central angle, base station to limb in radians

$\zeta \cdot r2d = 0.176$ degrees $\zeta \cdot \frac{Re}{1000} = 19.562$

$$\xi := acos\left(\frac{Re}{Re + hac}\right)$$ Central angle, aircralt to **limb** in radians

$\xi \cdot r2d = 0.396$ degrees $\xi \cdot \frac{Re}{1000} = 44.086$

$$mdist = (\zeta + \xi) \cdot Re$$

$\frac{mdist}{1000} = 63.648$ radius of area in which base stations can be seen by aircraft (km)

$\frac{mdist}{1.609 \cdot 1000} = 39.557$ miles $(\zeta + \xi) \cdot r2d = 0.572$

General model parameters

$m := 1000$ number of base station in view of aircraft

$t := 100$ number of trials of 'm' base stations

```
margin := | for j ∈ 0..t
          |   um_var ← 0
          |   or i ∈ 0 m
          |     staloc ← spread_cir(1, nidist)
          |     cent ← staloc_{0,1} / Re
          |     dist ← sqrt((Re + hbs)^2 + (Re + hac)^2 − 2·(Re + hbs)·(Re + hac)·cos(cent))
          |     arg ← ((Re + hac) / dist)·sin(cent)
          |     arg ← sign(arg)  if arg ≥ 1.0
          |     bs2ac ← acos(arg)
          |     bs2ac_tilt_deg ← bs2ac·r2d − tilt
          |     bsgaindisc ← Gbs2(|bs2ac_tilt_deg|)
          |     ac2bs ← π/2 − bs2ac − cent
          |     ac2bs_ant ← π − ac2bs
          |     ac2bs_ant_deg ← ac2bs_ant·r2d
          |     acgain ← Gac(|ac2bs_ant_deg|)
          |     ggrr ← bsgaindisc + acgain + dB(1 / (4·π·dist^2))
          |     cum_var ← cum_var + real(ggrr)
          |   cum_j ← −(dB(cum_var) + iso + EIRPm − limit)
          | cum
```

set loop for number of trials (I)
zero out variable to cumulate answer
'for loop' for number base stations in given trial
place BS at random distance 'staloc'(see 'spread−cir' function)

calc. geocentric angle from a/c to staloc (rad)

calc. distance from a/c to base station (m)

calc. look angle base station ant. to a/c (rad)
check for over flow of argument before taking 'acos'

calc. gain discrimination of base station antenna towards a/c taking into account antenna tilt

calc. aircraft to base station look angle (ac2bs)

assume a/c antenna is looking up and calc. off-axis angle (ac2bs_ant=180-ac2bs)

get gain from a/c to base station (acgain)

bts to a/c gain disc x ac to bs gain x spreading loss (in dBs)
cumulate gains x loss as real values

finished 'for loop' -convert real to dB and add isotropic antenna area, EIRP (in dBm) and subtract 'limit' to get difference between received power for m stations in view of aircraft and the saturation limit. A positive value implies received power is less than limit, i.e., a positive margin.

$$ave := dB\left(\frac{1}{t+1}\cdot\sum_{i=0}^{t} real\left(margin_i\right)\right)$$

$ave = 6.594$

$min(margin) = -0.166$

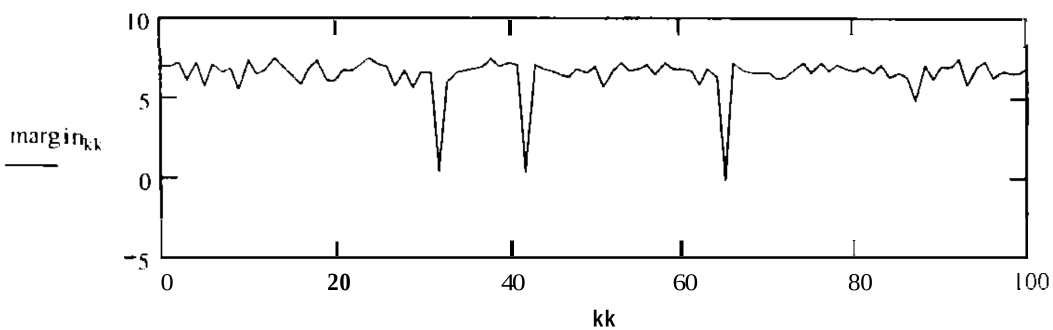
$max(margin) = 1.423$

'ave' **is** the average expected coupling **loss** between all of the base stations and the aircraft receiver. The aircraft gain, path **loss** and transmitter discrimination summed across all of the base stations are accounted for. The min and max are the highest and lowest values across all of the trials. Adding the transmit EIRP and other non-geometrically based gains and losses will yield Ihe power received by the aircraft receiver.

$n = 1 \times 10^3$ $hac = 152.367$

$t = 100$ $hbs = 30$

$kk := 0..t$



margin =

	0
0	6.956
1	6.887
5	5.706
6	7.08
7	[illegible]
8	6.846
9	5.438
10	7.27
11	6.394
12	6.73
13	7.423
14	6.9

This plot examines the change in isolation between the aircraft and the base Station as a function of the aircraft altitude.

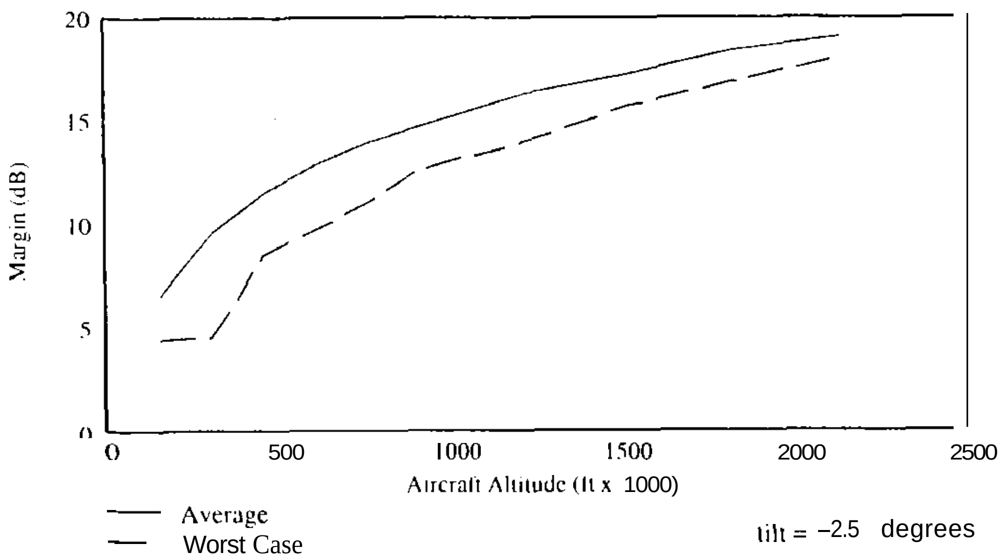
$k := 0..9$

Tilt Angle -2.5 Degrees

$$hei_{k,0} := \frac{hei_{k,0}}{1000} \cdot \frac{1}{1.609} \cdot \frac{5280}{1000}$$

convert altitude to (ft x 1000)

$$hei := \begin{pmatrix} 152.4 & 6.5 & 4.41 \\ 304.7 & 9.54 & 4.45 \\ 457.1 & 11.5 & 8.5 \\ 609.5 & 12.87 & 9.7 \\ 761.8 & 13.85 & 11.09 \\ 914.2 & 14.7 & 12.6 \\ 1219 & 16.19 & 13.91 \\ 1524 & 17.2 & 15.61 \\ 1821 & 18.28 & 16.74 \\ 2133 & 19.01 & 17.89 \end{pmatrix}$$



tilt = −2.5 degrees

APPENDIX C2 -- TECHNICAL EVALUATION OF L-BAND ATC PROPOSALS

Inmarsat has stated in response to the *Flexibility Notice* that granting MSV a license to use its proposed ATC system would lead to a number of interference situations with respect to the currently operating and future generation Inmarsat systems. In presenting its case, Inmarsat made a number of assumptions in calculating interference from both the ATC mobile earth terminals (ATC MTs) and ATC base stations. MSV analyzed Inmarsat's claims of potential interference, made certain other assumptions in its calculations, and came to more promising conclusions on the potential for interference to Inmarsat's networks. Below, we analyze the assumptions used in the competing analyses (Section 1, Assumptions), provide an individual assessment of the potential for interference from MSV's ATC operations to Inmarsat's networks (Section 2, Intra-Service Sharing) including land-based MSS receivers and receivers operating in the AMS(R)S and GDMSS services. and we evaluate the potential for interference that may be caused to other radiocommunication systems operating in frequency bands adjacent to MSV's proposed ATC system (Section 3, Inter-Service Sharing).

1.0 Assumptions Used in Analyses of Potential Interference

The following is an assessment of the assumptions used in the competing analyses contained in the record.

1.1 Polarization Isolation

Polarization mismatch loss is the ratio at the receiving point between received power in the expected polarization and received power in a polarization orthogonal toil from a wave transmitted with a different polarization. The polarization of an antenna remains relatively constant throughout the main lobe of the antenna pattern. but can vary considerably outside the mainlobe. In practice, polarization of the radiated energy varies with direction from the center of the antenna such that different parts of the antenna pattern and different sidelobes have different polarizations. When the locations of the transmitting and receiving stations are generally known and the analysis is considering mainbeam or near mainbeam antenna coupling, a polarization mismatch loss is included in the analysis.

Inmarsat references a value of 1.4 dB for polarization isolation for all cases of linear to circular, non-identical polarization mismatch between an MSV transmitter and an Inmarsat satellite receiver.[53] MSV argues that when an ensemble of randomly oriented linearly polarized emitters is received by a circularly polarized receiver, an isolation value of 3 dB should be used.[54] Because the orientations of the linear transmit ATC antennas will not be truly random" we take the more conservative 1.4dB number proposed by Inmarsat into account in our analyses.

Regarding orthogonal circular polarization. MSV states that a value of 8 dB would be appropriate for a near-off-axis circular polarized transmitter being received by an orthogonal circularly

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[53] Inmarsat Comments at 27

[54] MSV Reply at 8.

[55] It is expected that the ATC handset antennas will he oriented in some distribution about the local vertical and, therefore. will not hnve an equal probability of being oriented in all directions.

polarized receiver.[56] MSV has submitted both analytic and measured information in support of this claim.[57] The measurements provided by MSV cover the angular range from near-bore-sight to about 30 to 40 degrees off bore-sight for an Inmarsat Mini-M antenna. Therefore, our analysis uses **8** dB as the polarization isolation factor for. near boresite. orthogonal circular polarization cases. MSV proposes that the ATC base stations will employ LHCP. Other values of polarization isolation may be used in special situations, and an explanation is provided where the situation warrants a different number.

1.2 Signal Blockage in Urban Environment

In their comments and *ex parte* presentations. Inmarsat and MSV have used different values for signal blockage in their analyses of the potential for ATC MT interference to Inmarsat's satellites, MSV used a value of 15.5dB. which is a value that is supported by Dr. Wolfhard J. Vogel. who is an expert on L-band propagation.[58] In one of its **ex** *parte* comments, MSV proposed to reduce this value to 10 dB to be more conservative than the 15.5 dB originally used in its analyses.[59] Inmarsat. however, refers *to* the "Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems,"[60] and contends that the Handbook supports a "typical" blockage of only about ***2*** dB.

This "blockage" factor is the average attenuation or loss of signal strength between an ATC MT and a satellite receiver. Since the ATC system is proposed to be deployed in urban environments, it is expected that there will be some loss caused by structures such **as** buildings and trees between the ATC MTs and the satellite receivers. The debate on the value of the blockage factor revolves around the average loss that would result from a large number of ATC MTs. For the Inmarsat system, the blockage factor is imponant because it determines to what extent the ATC MT transmitter signals will increase its noise floor due to this potential interference environment. MSV has stated that it will limit its intra-system interference (self-noise from its own ATC system) to an increase in noise of 0.25 dB.[61] By setting its intra-system interference objective. MSV calculates the number of ATC MTs its system can support without receiving self-inrerference. This calculation ***is*** dependent upon the assumed "blockage" factor between the MTs and the MSV sarellite. Therefore. the assumed blockage between the MTs and the satellite receiver is imponant to both panies.

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[56] MSV Reply. Technical App. at 24

[57] ***See*** MSV May 1, 2002 *Ex Parte* Letter at 2-8.

[58] MSV Reply, Technical App. at 1-2 (incorporating statement by Dr. Wolfhard Vogel)

[59] MSV Jan. 10, 2002 ***Ex Pane*** Letter at 21

[60] Julius Goldhirsh & Wolfhard Vogel, *Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems*, (Dec. 1998), *available at* <http://www.utexas.edu/research/mopro/> (last visited. Feb 1, 2003)

[61] MSV Jan 10. 2002 *Ex Parte* Letter at 4

1.2.1 MSV's Proposed Blockage Factor

The value of 15.5 dB of blockage originally proposed by MSV was based upon an assumed distribution of ATC MT users. Specifically. the study by Dr. Vogel assumes that users would have a blockage factor of 13.8dB, users in buildings would have a blockage of 18 dB and users in vehicles would have a blockage of 21.3 dB.[63] The study also distributes the user population according to the following in Table 1.2.1.A.

Table 1.2.1.A: Distribution of ATC MTs and Associated Blockage Factor

Location	Users	Blockage (dB)
Outdoors		-13.8
In Vehicles		-21.3
In Buildings	40	-18.0
Average Loss		-16.8

This user distribution results in an average blockage factor of 16.8 dB. Based upon this calculation. MSV contends that its blockage factor of 10 dB is conservative. In addition, the study by Dr. Vogel indicated that, for a handheld MT, the user also blocks the signal by an additional 3 dB due to Radio Frequency (RF) absorption by the human head and body.[64] This "body blockage" was accounted for in the typical blockage factors listed in Table 1.2.1.A.

1.2.2 Inmarsat's Proposed Blockage Factor

Inmarsat refers in its Comments and *ex pane* presentations to the "Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems" which was authored in part by Dr. Vogel. Inmarsat contends that the Handbook supports an "average blockage" of only 1.9 dB.[65] Specifically, the figure used in Inmarsat's *ex parte* presentation is reproduced below as Figure 1.2.2.A (Figure 10-4 from the Handbook). The left hand portion of Figure 1.2.2.A shows the probability that a specific user-to-satellite loss will occur according to a number of different blockage models. As can be seen in the figure, the fiftieth percentile loss is about 3 dB. This would indicate that 50% of the users would experience a loss greater the 3 dB and 50% less than 3 dB. Since this figure is for a satellite seen at an elevation of 32 degrees, the average (50th percentile) loss due to urban blockage can be taken as 3 dB as opposed to Inmarsat's 1.9 dB

[62] If the user is on the street in an urban setting. buildings and other structures would attenuate the ATC MT signals.

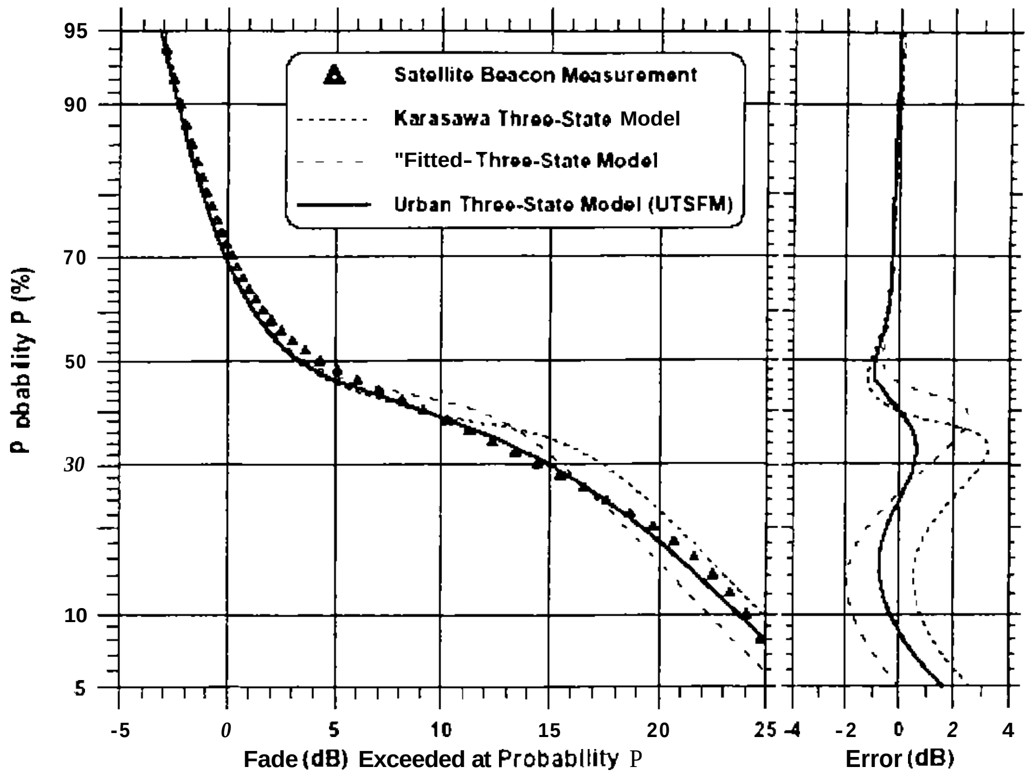
[63] The 21.3dB is composed of two parts: 7.5 dB from being inside the vehicle and an additional 13.8 dB from being outdoors on the street in an urban setting

[64] *See* Toftgaard. J., IEEE Transactions on Antennas and Propagation, *Effects on Porrable Antennas of the Presence of a Person*, Vol. 41. No. 6, (June 1993). Measurements were carried out on GSM and DECT handheld cellular phones, at 900 MHz and 1800 MHz. Between 45% and 55% of the transmitted power was absorbed by the head and body or the cell phone user. yielding a loss of signal due to 'body blockage' of between 2.6 and 3.5 dB

[65] To put the blockage values (given in dB) into context. a blockage value of 15 dB corresponds to a signal reduction between the ATC MT and the Inmarsat satellite by a factor of more than 30; MSV's blockage value of 10 dB corresponds to a signal reduction by a factor of 10; and Inmarsat's blockage value of 1.9 dB corresponds to a signal reduction of only 1.5.

value. Inmarsat assumes that all ATC users will be located outdoors and no additional attenuation from operations inside vehicles or inside buildings is taken into account.

Figure 1.2.2.A: Handbook Figure 10-4



In the Handbook discussion, the elevation angle from the MT to the satellite receiver is a very important parameter in determining attenuation due to blockage. This parameter is not evaluated by Inmarsat in its analysis. The data used to produce Figure **1.2.2.A was** derived by the satellite located with a **32**" elevation angle with respect to the MT. Figure 1.2.2.B, below, is taken from Figure 10-5 of the Handbook. This figure represents data on the change in blockage to a satellite **as** the elevation angle to the satellite is varied.

Figure 1.2.2.B: Handbook Figure 10-5

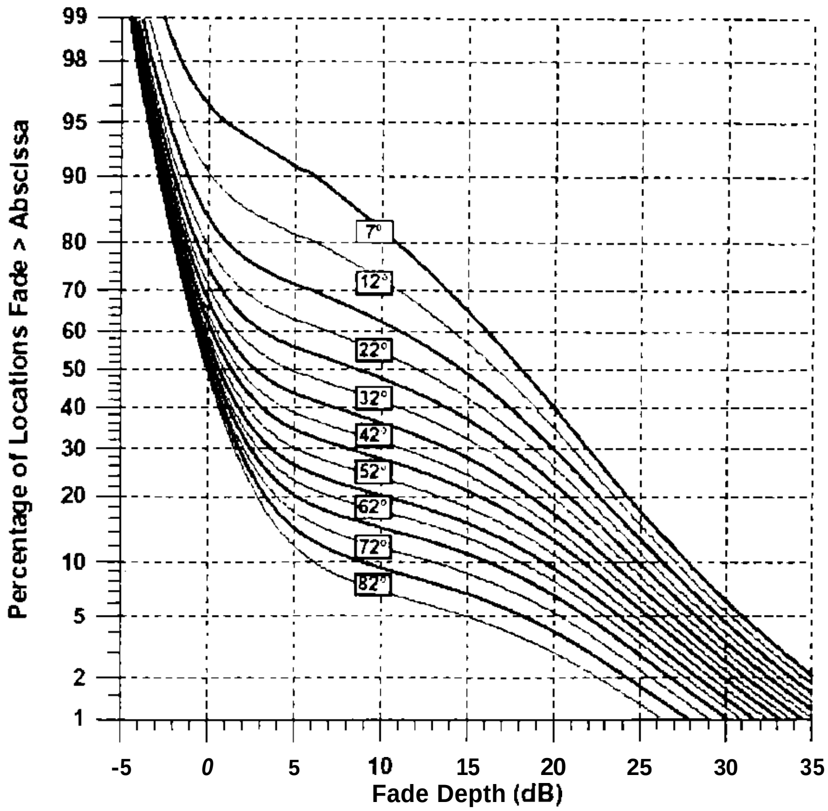
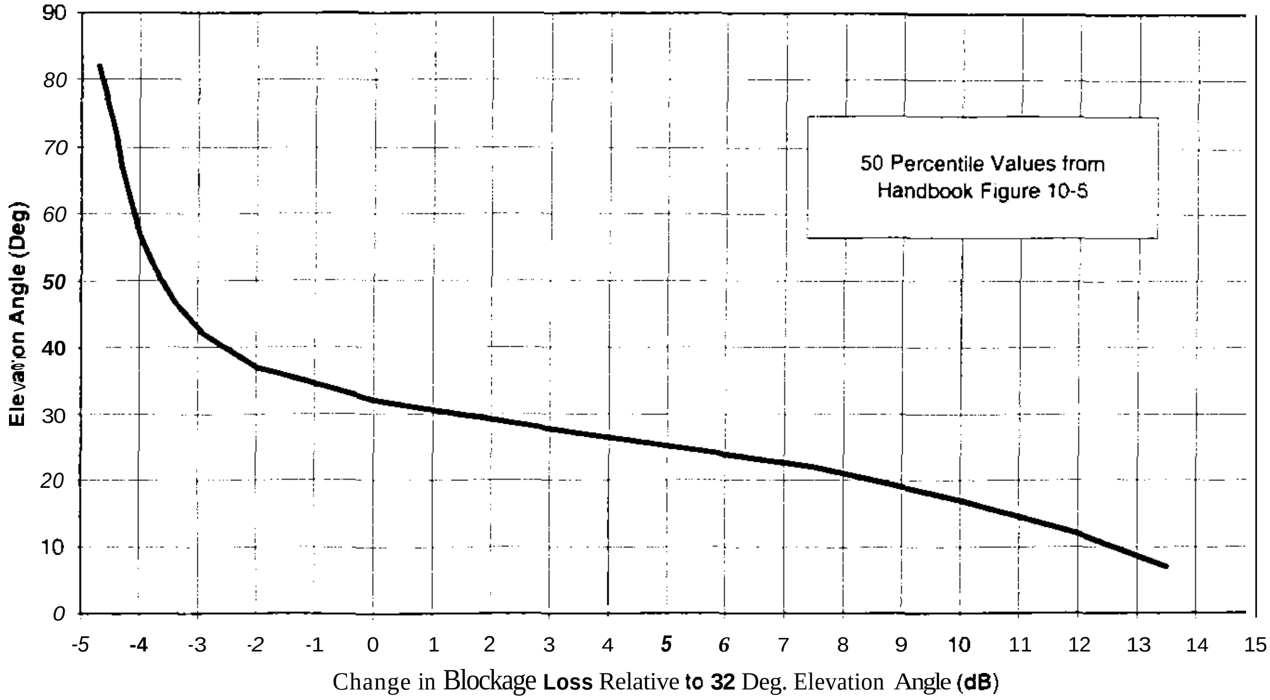


Figure 1.2.2.C shows the expected difference in attenuation, due to blockage. as a function of satellite elevation angle for the 50th percentile. The data used in Figure 1.2.2.C is directly derived from Figure 1.2.2.B. Figure 1.2.2.C indicates that the blockage factor increases significantly as the elevation angle to the satellite decreases. For example. the attenuation due to blockage would be 7.5 dB higher for a satellite seen at 22 degrees elevation when compared with one at 32 degrees. Conversely, if the elevation angle is raised by 10 degrees **(from 32** to 42 degrees) the average blockage decreases by only about 3 dB. In sum, the amount of signal blockage increases very rapidly as elevation angles to the satellite decrease.

Figure I.Z.Z.C: Change in Blockage with Satellite Elevation Angle (50th Percentile)



1.2.3 Analysis of Elevation Angles on Average Outdoor Blockage

Inrnarsat currently operates the Atlantic Ocean Region-West (AOR-W) satellite at 54° W.L., the Atlantic Ocean Region-East (AOR-E) satellite at 15.5" W.L. and the Pacific Ocean Region (POR) satellite at 142° W.L. The average elevation of these satellites to the 48 Contiguous United States (CONUS) is relatively low.[66] MSV's satellite currently operates at the 101° W.L. orbital location. Table 1.2.3.A shows the elevation angles from a number of locations in CONUS to the MSV satellite and the various Inmarsat satellites.

[66] Inmarsat has begun to coordinate an additional satellite at 98° W.L. but, due to the time involved, coordination has not been reached and the satellite has not been launched into that orbital location.

Table 1.23.A: Elevation Angles to Various Cities as seen from Operating L-band Satellites

GSO Location	Inmarsat AOR-E 15.5 W.L.	Inmarsat AOR-W 54 W.L.	Inmarsat POR 142 W.L.	MSV 101 W.L.
Washington	14.0	40.7	11.2	40.2
Boston	16.3	38.1	5.3	32.5
Miami	14.3	48.4	16.9	52.2
Dallas		30.6	29.0	51.9
Denver		20.8	30.4	43.9
Bismarck	5.1	32.3	18.0	41.5
Seattle		7.4	37.2	36.7
San Francisco		8.5	41.9	41.2
San Diego		14.0	43.7	48.4

Satellite	Avg. Blockage At 32 deg.	Avg. Blockage Rel. to 32 degree	Expected Avg. Outdoor
MSV	-3.0	+2.5	-0.5
AOR-W	-3.0	-0.1	-3.1
POR	-3.0	-3.3	-6.3
AOR-E	-3 0	-14 5	-17.5

1.2.4 Average Outdoor Blockage Factor Used in Analyses

The above analysis demonstrates that the currently operating lnmarsat satellites should have about 2.5 dB more outdoor blockage than the outdoor blockage to the MSV satellite. An average blockage factor of about -3 dB can be expected between an ATC MT transmission and an lnmarsat satellite. while an outdoor blockage factor of about -0.5 dB would be available to the MSV satellite.

1.3 Power Control[67]

The power control system is used within a cellular system to equalize the power received at the base station antenna and to minimize the power transmitted by both the base station and MT. This reduces both the inter- and intra-cellular interference in the system and maximizes the battery life in the MT.

lnmarsat assumes a 2 dB power control factor for the MSV MTs. MSV. however, maintains that a 6 dB power control factor would be appropriate. Inmarsat provides no rationale for its *2* dB assumption except that the actual value is expected to be dependent on the MT deployment scenario. MSV provided a deployment scenario that results in a 7.5 dB power control factor by its calculation.[68] MSV then states that closed loop power control will reduce average emissions by at least 6 dB.

MSV's argument for a 6 dB MT power control factor is based upon the fact that with a closed loop power control system the transmit power of a MT will be a function of the blockage between the MT and the base station. MSV assumes a population of ATC users distributed with some users in buildings and some outside of buildings. MSV further assumes that the ATC system will have a maximum link margin of 18 dB reserved to overcome blockage between the MT and the base station. MSV then calculates the average amount of blockage margin that is required to overcome the average blockage experienced by the MT population (10.5 dB) and contends that the power control factor will be (18-10.5 =) 7.5 dB. In other words, the average MT will represent a potential interference source (18-10.5 =) 7.5 dB below the peak MT transmit power. This rationale is used to show that a power control factor of *6* dB is conservative.

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[67] For purposes of the present discussion, we consider "power control" to be comprised exclusively of (i) range compensation (also known as "range raper"): (ii) structural attenuation: and (iii) body absorption. Although some commenters include other attenuation factors within their individual conceptions of "power control," we consider other attenuation factors. including building blockage, separately.

[68] *See* MSV Reply, Technical **App.** at 6-7

If, as stated above, the power of the MT is absorbed locally (and therefore does not contribute to interference), and the MT is operating at or near its maximum power, only half of that power will radiate out and be capable of contributing to any interference. The peak radiated power from a 1 Watt handheld MT, therefore, will only be ½ Watt, whereby the remaining ½ Wau is absorbed by the user. By assuming that body absorption makes no contribution to a reduction in interference potentially caused by **an** MT, we are being conservative.

1.3.5 Summary of Power Control and Blockage

The power control system is used to compensate for a number of different factors:

- Range Compensation – which will vary from about 3 to ***6*** dB based upon the design of the cellular system. For example. in a cellular system based upon hexagonal cells the range compensation factor will be about ***6*** dB, while in a cellular system based upon circular cells will have a value of about ***3* dB**.[76] The actual value will also depend upon the propagation parameters assumed within the cell.

- Structural Attenuation – which can vary from about 10 to 20 dB based upon the design and purpose of the ATC cellular system. For example, the COMTEK report assumed 10 to 20 dB of structural attenuation would typically be budgeted within the system.[17] MSV asserts that, per standard PCS design practices, 18 dB of building penetration margin is allocated to the available link margin at edge of **coverage.**[78] **A** value of 10 dB appears to be typically for structural attenuation from other sources.[19]

- Body Adsorption – which must also be accounted for by the power control system and can vary from 2 to **4 dB**.[80]

In proceeding with our analysis we will assume an average value power control factor of 20 dB in the MT to BS link. This factor, as explained above. applies independent of the distribution of ATC users. Our analyses is based on the expectations that MSV will implement the full 18 dB of margin for structural attenuation that they state is "per standard PCS design practices" and that they will implement the maximum dynamic range of power control contained in the GSM system specification.

In the BS-to-MT direction. the ATC user distribution used by MSV (and discussed below in section 1.2.1) consisted of 40% of users in buildings which would use the full structural attenuation. **30%** of the users in vehicles and 30% of the users in the open. This distribution leads to a base station to MT power control factor of 2.2 dB as shown in Table 1.3.5.A and a total

[76] Sprint/Cingular Telcordia **Study.** Attach. A, at 19-20

[77] ***See COMTEK*** *Associates Report* at 59

[78] MSV Reply Comments. Technical App. at 6-7

[79] *See. e.g.*, http://150.250.105.16/~krchnave/spring2002/wireless/Kluwer_CD/chaptr04/outage/linkbudg.htm.

[80] See Toftgaard *supra* note 65.

- the other 50% of the users are located in buildings with 80% of these users being near windows and having 10 dB structural attenuation and 20% being in the building's interior and having 18 dB of structural attenuation.[71]

Under these circumstances, the base station would have to increase its power by an average of 10.5 dB, across all users. to compensate for the structural attenuation of all of the users. The base station transmit power available to potentially cause interference will be (-18+10.5 =) -7.5 dB below the hase station peak power.

13.3 Power Control for Range Compensation

In addition to structural attenuation. the power control system compensates for the "near-far" problem. Simply put, the closer the MT is to the base station the less power is required to communicate between the two. For example. if the user initially starts at the edge of coverage of the cellular system and walks towards the base station. the power control will reduce the amount of power transmitted as the distance between the user and base station is reduced. The amount of reduction, as a function of separation distance. depends upon the propagation characteristics that occur in the cell. In open areas, the propagation loss is characterized as a function of the separation distance squared. In urban and city settings, the propagation loss can be **a** function of the separation distance taken to the third or fourth power." The average range compensation loss is also a function of the way power control **is** implemented depending upon the size of the power control step and the number of power control steps. Sprint and Cingular submitted an ex pane study conducted by the Telcordia Technologies that contains an analysis of range compensation power control for a cellular system assuming a hexagonal cell packing **structure**.[73] The analysis assumes a path **loss** exponent'' of 3.5 and concludes that this portion of the power control will result in an average power reduction factor of 6 dB. This factor would apply to both the MT and the base station.

1.3.4 Body Absorption or Body Blockage

As mentioned in Section 1.*2*.I, about half of the transmit power of **a** handheld MT is absorbed by the person operating the MT.[75] This phenomena will result in a **3** dB increase in transmit power in both the MT and base station. In the case of the MT. the power will be absorbed locally, by the user, and will not contribute to any type of interference. The resulting increase in power at the base station will radiate into space and could potentially contribute to an interference situation.

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[71] ***See*** MSV Reply, Technical Annex at 7

[72] For example, the Egli Path Losa model. *see Radio Propagation* ***Above 40*** *MHz* ***Over*** *Irregular Terrain* Proc. IRE, Vol. 45. Oct. 1957 at 1383-91. assumes that path loss is proportional to distance raised to the fourth power The Hata Model assumes that path loss varies as a function of transmiller length. *See* J.S. Lee & L.E. Miller, CDMA *System Engineering Handbook* (Boston: Air Tech House 1998).

[73] Sprint/Cingular Telcordia Study, Attach. A at 19-20

[74] RF propagation loss in free space is assumed to be proportional to the disiance squared (D^2). Another way of expressing this is to say that the propafation loss assumes a path loss exponent of 2. Propagation models for urban settings result in path loss exponents of between 3 and 4 depending upon the model used

[75] *See* Toftgaard *supra* note 65

Space System	Downlink Band	Uplink Band
Inmarsat	-188.2	-188.7
MSV	-187.8	-188.3

[84] *See* National Institute of Standards and Technology. Wireless Communications Technology Group. *General Purpose Calculator for Outdoor Propagation Loss*, *available at* <http://w3.antd.nist.gov/wctg/manet/prd_propcalc.html> (last visited, Jan. 30. 2003) (offering propagation software).

	Inmarsat	MSV	Staff
Range Compensation	2.0	6.0	6.0
Structural Attenuation	0.0	10.0	***2.2***
Body Blockage	0	3.0	**-3.0**
Total	2.0	19.0	5.2

[81] *See* ETSI Standard 300 609-1 and 300 609-4.

[82] *See* 47 C.F.R. § 24.238.

[83] MSV Comments, Technical App., Ex E at 1-8

1.9 Voice Activation Factor

A typical value for voice activation is in the range of *2* to **4** dB depending upon the system and the background noise at the location of the MT. MSV uses a value of 1 dB for the MT since it will likely be used in a noisy environment. It uses 4 dB for the base stations which assumes that the traffic it transmits will originate in a much less noisy environment than the handheld user MTs. These values *are* incorporated into our analyses.

Voice activation can also be used to account for the number of active BS carriers in a single cell sector, at a given instant in time due to voice usage. In the MSV system architecture there are three carriers in each sector and each carrier will either be on or off in each TDMA time slot because of voice effects. There is a long-term voice activation over several frames that further reduces the long-term average power. However. the power in a time slot is of primary concern since the GSM time-slot duration is 0.577 milliseconds and each time slot can impact several symbols of a digital message of another system. If it is assumed that two of the three carriers will be transmitting in the same time slot, the voice activation factor will be 1.8dB. In our analysis, a voice activation factor of 1 dB is used for an aggregation of MTs, **4** dB is used for an aggregation of BS and 1.8 dB is used for a single BS sector.

1.10 Voice Encoder (Vocoder) Factor

MSV contends that use of voice encoders, or **vocoders,**[86] will reduce the amount of power from the MTs that would potentially interfere with the Inmarsat satellites. MSV maintains that a 7.4 dB reduction in interfering power could be associated with its use of a **2.4** kbps vocoder and that it is possible for some of its MTs to use **2.4** kbps while the remainder of its MTs use various vocoder rates between **2.4** and **13** kbps.

MSV asserts that a terminal that is terrestrially engaged in voice communications will be allocated the highest rate vocoder, and, will thus, be operating in full-rate GSM mode. MSV further asserts that, when its output power as reported to the system by the terminal exceeds an upper bound (say -10 dBW). that terminal will. via fast in-band signaling, be commanded to switch over to quaner-rate **GSM** mode (equivalent to sarellite-mode). In this mode. that terminal now needs to transmit only one GSM burst once in every four GSM frames." If an algorithm that **links** the data rate associated with a specific user terminal to that user terminal's transmit power level is incorporated in the ATC system, the effective power of the user would be reduced by 7.4 dB. That is. the vocoder data rate can be used in conjunction with the active power control to reduce interference at the expense of total sysrem capacity. This can be done by having user terminals requesting high transmit powers automatically switched to lower data rates, and, therefore, make fewer transmissions. This lower effective data rate lowers the effective or average power of the user while actually increasing the amount of power available for structural attenuation on a per-burst basis.

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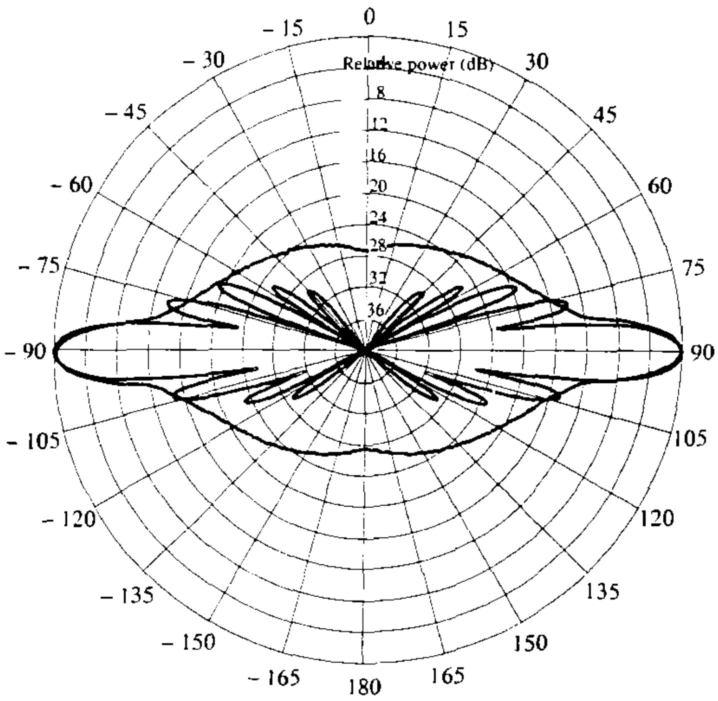
[86] Voice encoders are used to digitize the human voice for delivery over a digital communications system. The quality of the reproduced voice depends upon the algorithms used to encode and decode voice and the data rare of the resulting digital voice represenlation. The standard GSM vocoder data rate is about 13 kbps. **MSV** maintains that using **an** algorithm with a data rate of 2.4 **kbps** would reduce the power of all users by 7.4 dB (10*log(13/2.4)).

[87] MSV Jan. *39.* 2003 *Ex Parte* Lerter ar 3.

from an L-band ATC base-station antenna visible at high elevation angles to airborne receivers.''
The isolation value proposed by Inmarsat is about 10 dB based upon the reference pattern contained in the Recommendation. The antenna radiation pattern from the ITU-R is incorporated below as Figure 1.8.A.

Figure 1.8.A: Antenna Radiation Pattern (Figure 5, of Recommendation ITU-R F.1336)

Note – high values of gain discrimination at elevation angles above about 15 degrees (i.e., between –75° and +75° as shown on the figure).



This Figure compares a measured 900 MHz antenna pattern to its corresponding reference pattern. The measured pattern shows a significantly greater isolation than predicted by the reference pattern for elevation angles 30 degrees or greater from boresight. For elevation angles above 45 degrees from boresight, it appears that isolations above 36 dB are achievable, even with an antenna not specifically designed for ATC operations. This showing supports MSV's assertion that it is possible to obtain 40 dB of isolation above the base station antenna.

Inmarsat also contends that the tilt angle of the ATC base station antennas will be important. MSV indicared that the antenna tilt will be –5 degrees. This factor is taken into account in determining the potential for interference to aircraft terminals operating over the Inmarsat system

[85] *See* International Telecommunications Union. Recommendation ITU-R F.1336. *Reference Radiation Patterns of Omnidirectional, Sectoral and Other Antennas In Point-To-Multipoint Systems For Use In Sharing Studies In The Frequency Range From 1 GHz To About 70 GHz.*

Assuming that various vocoder rates range between 13 kbps and 2.4 kbps, Table 1.10.A shows the number of TDMA frames that would be skipped between MT transmission, the associated transmit duty cycle and transmit power of the MT. If a vocoder is implemented, the power increase and duty cycle would balance so that the time-averaged transmit power would remain constant. It **is** our expectation that the TDMA time-slots vacated by an MT in order to reduce its transmit duty cycle would not be utilized by another MT.

Table 1.10.A Vocoder Associated Transmit Power and Duty Cycles

Vocoder Rate (kbps)	No. Skipped TDMA Frames	MT Transmit Duty Cycle	Transmit Power (dBW)[88]
13	0	100 %	X
6.5	1	50 %	X+3.0
3.25	3	25 %	X+6.0
2.6	4	20 %	X+7.0
2.4	Average of 4.4	18.2 %	X+7.4

Unlike the MT to BS power control factor. the average power reduction obtained by using a vocoder will be dependent upon the distribution of users. For example, if a user is within a building at the maximum structural attenuation, the MT will be transmitting at the peak power of 0 dBW, however, the duty cycle of the MT will be at 18.2%. The time averaged power radiated out of the structure by the MT will be 7.4 dB below the maximum amount of structural attenuation budget in the cellular design (i.e, on a time-averaged basis the reduction in duty cycle will lower the effected radiated power by 10*log(18.2/100) = 7.4 dB). A user in an automobile near the edge of the cell will be operating somewhat below the maximum amount of structural attenuation budget in the cellular design at a duty cycle of perhaps 25%. An outdoor user would be operating with the GSM 13 kbps vocoder operating at 100% duty cycle. Table 1.10.B calculates the average power reduction factor resulting from the use variable rate vocoder based upon these assumptions and the user distribution described by Dr. Vogel given in subsection 1.2. While MSV states that the vocoder reduces the effective interference power by 7.4 dB, Table 1.10.B indicates that a vocoder factor of only 3.5 dB should be used in our interference analyses.

[88] In this instance 'X' is intended to stand for a specific level of MT transmit power. This specific level could depend on a number of factors such as the allowable structural attenuation, permitted peal power, etc.